Rio Blanco Oil Shale Company

MODULAR DEVELOPMENT PHASE MONITORING REPORT EIGHT

Volume 1 of 2

December 1980 — May 1981

Mid Year Report

Gulf Oil Corporation/Standard Oil Company (Indiana)
A General Partnership
2851 South Parker Road, Aurora, Colorado 80014

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MONITORING REPORT 8

December 1980 - May 1981

MID-YEAR REPORT

Prepared by:
RIO BLANCO OIL SHALE COMPANY
DENVER, COLORADO

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CHAPTER 1

INTRODUCTION

In 1969, the U.S. Department of the Interior initiated planning for a prototype oil shale leasing program. Under this program, Gulf Oil Corporation and Standard Oil Company (Indiana) in 1974 acquired the oil shale lease for Tract C-a in the Piceance Creek basin of northwest Colorado. These two companies are now operating the tract under a general partnership called the Rio Blanco Oil Shale Company (RBOSC).

Since its inception, RBOSC has been conducting extensive programs to collect environmental data. Between October 1974 and September 1976, two years of baseline data were gathered. From September 1976 through August 1977, interim environmental data were collected during the period in which RBOSC had suspended tract development activities. In August 1977, RBOSC launched their Modular Development Phase (MDP) Environmental Monitoring Program. The first report of MDP environmental activities (September - November 1977) was published in February 1978. Subsequent reports were published in September 1978; March and August 1979; March and August 1980; and March 1981. The current report represents RBOSC's eighth MDP Monitoring Report, and covers the period from December 1980 - May 1981.

The RBOSC MDP Environmental Monitoring Program provides data on air quality, meteorology, terrestrial ecology, aquatic ecology, and hydrology and special studies. Monitoring program designs are based on analysis of baseline and interim studies data, an assessment of probable developmental impacts, and recommendations from the Oil Shale Office (OSO). The monitoring conducted during December through March of this reporting period was done in accordance with Revision 5.2 of the RBOSC Modular Development Phase Environmental Monitoring Program Scope of Work, dated March 30, 1979 and approved by the OSO on April 26, 1979, with 17 Conditions of Approval. During the remainder of the reporting period, April and May, the monitoring was conducted in accordance with Revision 6.2 of the RBOSC Modular Development Phase Environmental Monitoring Program Scope of Work, which was dated February 25, 1981 and approved by the OSO on May 1, 1981, with eight Conditions of Approval. This scope of work reflects the environmental monitoring philosophy set forth in RBOSC's Revised Detailed Development Plan, May 1977.

Major responsibility for monitoring program activities rest with personnel in the RBOSC Environmental Affairs Department. Several consultants were used in various capacities during this reporting period, however. They include: Mr. J.R. Fleming (air studies data handling), Morrison-Knudsen (operational hydrology), MARIAH Associates (aquatic studies), and USGS (surface water gaging station program). Section 4.0 - Aquatic Studies - was prepared by MARIAH Associates. Visibility studies were carried out in a joint effort with Cathedral Bluff's Shale Oil Venture (Tract C-b).

Data collected during MDP monitoring studies are reported semi-annually, in a mid-year and a year-end report. Monitoring Report 8, the fourth mid-year data report, presents the data collected for the six-month period, a summary of the winter and spring data, brief discussions of the data, comparisons of the winter and spring 1979 data with previous data where applicable, and notations on any impacts which may have been caused by initial development activities.

Objectives of the monitoring program are presented herein. Methods are presented only if they differ from those presented in previous RBOSC MDP Monitoring Reports, if clarification is required, or if methods have not been reported previously. The "Special Studies" section discusses studies that are conducted periodically or opportunistically, and provides a format for presenting data that might otherwise be obscured. Volume 1 of this report contains eight sections as follows:

Section 1 - Introduction
Section 2 - Atmospheric Studies
Section 3 - Terrestrial Studies
Section 4 - Aquatic Studies
Section 5 - Hydrology Studies
Section 6 - Special Studies
Section 7 - Ecological Interactions
Section 8 - Summary

Volume 2 contains the following appendices:

2-1 Air Quality Data

2-2 Meteorological Data

2-5 Visibility Data

3-1 Vegetation Data

3-2 Fauna Data

4-0 Aquatic Data

5-1 Surface Water Data

5-2 Ground Water Data

5-3 Development Activities Monitoring Data

SECTION 2

ATMOSPHERIC STUDIES

The Tract C-a atmospheric studies program consists of two elements: (1) measurements of total suspended particulate matter and certain gaseous chemical compounds, and (2) measurements of selected meteorological parameters. The monitoring locations were originally established to measure the ambient air quality generally upwind and somewhat removed from the expected tract development, and at points where tract developments might have an effect on the air quality. Simultaneous meteorological measurements are being made to allow evaluations of air quality changes and for the prediction of the dispersion of emissions resulting from tract development.

Air quality and meteorological data have been obtained from monitoring instruments located on or near Tract C-a since February 1975. The first two years of data collection make up the baseline data set. Data from the baseline period were obtained at four locations around the tract. Following the baseline period, an interim data acquisition program was established to cover an interval during which the tract development lease conditions were modified and partially suspended. During the interim period (February through August 1977), a single air quality and meteorological monitoring station was operated to maintain data continuity.

The current program is part of the Modular Development Phase (MDP). The level of activity on the tract, principally construction work, has increased significantly during the MDP period. The monitoring program has been strengthened in order to measure possible effects of increased tract activity on the ambient air quality. Two of the sites that had been deactivated for the interim period were refitted with meteorological instrumentation and put back on-line during the first quarter of the MDP. In addition, one of the reactivated meteorological sites has been refitted with a complete set of air quality instrumentation (Table 2-1).

Table 2-1. Air Studies Monitoring Parameters and MDP Program Schedule, Tract C-a

Parameter	Location	Start Date	Frequency
Sulfur Dioxide	Site 1 Site 3 Site 5	Sept. 1977 Jan. 1978	Continuously Continuously Not defined yet
Nitrogen Oxides	Site 1 Site 3	Sept. 1977 Feb. 1980	Continuously Continuously
Nitric Oxide	Site 1 Site 3	Sept. 1977 Feb. 1980	Continuously Continuously
Hydrogen Sulfide	Site 1 Site 3	Nov. 1977 Jan. 1978	Continuously Continuously
Carbon Monoxide	Site 1 Site 3	Oct. 1977 Feb. 1980	Continuously Continuously
Hydrocarbons(1)	Site 1	Sept. 1977	Continuously
Ozone	Site 1 Site 3	Sept. 1977 Nov. 1977	Continuously Continuously
Particulates	Sites 1, 2, 3 Site 6[1/]	Dec. 1977 Dec. 1977	Every 3rd day Every 3rd day
Wind direction (10m)	Sites 1, 2, 3	Sept. 1977	Continuously
Wind direction (60m)	Site 1	Sept. 1977	Continuously
Wind speed (10m)	Sites 1, 2, 3	Sept. 1977	Continuously
Wind speed (60m)	Site 1	Sept. 1977	Continuously
Wind sigma (10m)	Site 1	Sept. 1977	Continuously
Ambient temperature (10m)	Sites 1, 2, 3	Sept. 1977	Continuously
Temperature differential (10-60m)	Site 1	Sept. 1977	Continuously
Precipitation	Sites 1, 2, 3 & other selected locations	Oct. 1977	By event
Snow depth and accumulation	Sites 1, 2, 3	Nov. 1978	By event
Solar radiation	Site 1	Sept. 1977	Continuously
Dewpoint (10m)	Site 1	July 1978	Continuously
Visibility	Visibility Shelter	Spring 1978	Semi-annually
Noise	16 locations on tract	Jan. 1978	Quarterly

1/ discontinued by agreement with OSO

2.1 AIR QUALITY

Air quality monitoring is being conducted on and near Tract C-a to measure the concentrations of certain pollutants which may be emitted by tract operations. The ambient air quality monitoring network consists of two locations where gaseous constituents are measured (Sites 1 and 3) and three locations where particulate concentrations are measured (Sites 1, 2, and 3). Sites 1 and 2 generally measure background ambient air quality, while Site 3 is located in a broad gulch that may have some air quality changes due to dispersion under down-valley flow from the main development area in the center of the tract.

All of the air quality data, with the exception of the particulate data, are collected on automatic monitoring equipment and recorded on digital computer tape and backup strip charts by a data acquisition system. The data on the digital tape are averaged into hourly values. High volume samplers are used to collect 24-hour samples of particulate data every third day at three sites.

A cooperative visibility study (with Tract C-b) was conducted during the baseline period, and has been conducted each Spring and Fall since 1978 as part of the air studies program. These data will allow detection of any trends in the visual range in the Piceance Creek Basin. However, the Spring visibility study was completed after the end of this reporting period. The data and results will be included in the year-end report.

Air quality data taken during the twelfth and thirteenth quarters of the MDP program are presented in Appendices 2-1.1 (gaseous constituents) and 2-1.2 (total suspended particulates).

A. Sulfur Dioxide

1. Objectives

The objective of monitoring for sulfur dioxide is to establish the ambient air concentration prior to and during tract development. The existing sulfur dioxide levels and their associated environmental effects can be compared to future environmental changes that may be related to any increase in the concentration of sulfur dioxide.

2. Methods

The methods followed for collection of sulfur dioxide data were described in RBOSC MDP Monitoring Report 5.

3. Results and Discussion

Maximum SO_2 concentrations during this reporting period were 0.036 ppm at Site 1 and 0.014 ppm at Site 3, while the mean SO_2 concentrations were 0.003 at both sites. (Table 2-2).

B. Hydrogen Sulfide

1. Objectives

The objective of monitoring hydrogen sulfide in the ambient air on the tract is to establish the background value. Tract development, which will involve recovery of sulfur-bearing organics, may release hydrogen sulfide into the ambient air. Concentrations of this constituent in the future may be compared to pre-development conditions to assess environmental impacts.

2. Methods

The methods followed for collection of sulfur dioxide data were described in RBOSC MDP Monitoring Report 6.

3. Results and Discussion

Maximum H_2S concentrations during this reporting period were 0.015 ppm at both sites while the mean H_2S concentration was 0.004 ppm at Site 1 and 0.005 ppm at Site 3 (Table 2-2).

Table 2-2. Summary of Air Quality Data Collected Between December 1980 and June 1981, Tract C-a

Parameter	Units	Minimum[1/]	Maximum[1/]	Arithmetic Mean
		Site 1		
SO_2	ppm	0.002	0.036	0.003
H_2S	ppm	0.002	0.015	0.004
NO	ppm	0.005	0.061	0.006
NO_x	ppm	0.005	0.039	0.006
CO	ppm	0.5	0.5	0.5
O_3	ppm	0.021	0.070	0.044
TSP[2/]	$\mu g/m^3$	5.	41.	14.[3/]
		Site 2		
TSP[2/]	$\mu g/m^3$	4.	49.	13.[3/]
		Site 3		
SO_2	ppm	0.002	0.014	0.003
H_2S	ppm	0.002	0.015	0.005
NO	ppm	0.005	0.027	0.005
NO_x	ppm	0.005	0.028	0.005
CO	ppm	0.5	0.5	0.5
O_3	ppm	0.003	0.066	0.031
TSP[2/]	$\mu g/m^3$	6.	57.	20.[3/]

1/ Hourly average

2/ 24-hour averages

3/ Geometric Mean

C. Nitrogen Oxides

1. Objectives

Nitrogen oxides are monitored to establish the existing natural background levels prior to major tract development and operation. Tract operations will involve substantial combustion with the possible generation of nitrogen oxides. Reaction between nitric oxide and hydrocarbons in the presence of sunlight could result in the local production of ozone.

2. Methods

The methods followed for collection of nitrogen oxides data were described in RBOSC MDP Monitoring Report 2.

3. Results and Discussion

The concentrations of both nitric oxide and nitrogen oxides were below the threshold of detection most of the time during the current year, so that the mean of both these variables at Sites 1 and 3 during the last six months was at or below 0.006ppm (Table 2-2). The maximum concentrations during this period at Site 1 were 0.061 ppm for NO and 0.039 ppm for NO_x, while at Site 3 the maximums were 0.027 and 0.028 ppm, respectively.

D. Carbon Monoxide

Carbon monoxide results from the incomplete oxidation of carbon during combustion.

1. Objectives

Carbon monoxide is monitored to establish the ambient air concentration of this constituent prior to and during tract development activities. Vehicular use and fuel combustion during tract development may result in the emission of carbon monoxide in the tract area.

2. Methods

The methods followed for collection of carbon monoxide data were described in RBOSC MDP Monitoring Report 2.

3. Results and Discussion

The maximum and mean concentrations of CO during this period at both sites were 0.5 ppm.

E. Ozone

1. Objectives

Ozone monitoring is conducted to establish the ambient air concentration of this constituent prior to and during tract development and operation. The potential emissions of nitrogen oxides coupled with hydrocarbons and strong sunlight may produce photochemical reactions in the future in the tract area.

2. Methods

The methods followed for collection of ozone data were described in RBOSC MDP Monitoring Report 2.

3. Results and Discussion

The range of ozone concentrations was 0.021 to 0.070 ppm at Site 1 and 0.003 to 0.066 ppm at Site 3, while the mean concentrations were 0.044 and 0.031 ppm, respectively (Table 2-2). The primary hourly national ambient air quality standard (NAAQS) of 0.12 ppm was not exceeded during the period at either site.

A very strong diurnal variation with a daytime maximum occurred at Site 3, with a much weaker diurnal cycle at Site 1. This pattern is similar to that found in the data of previous years (see Monitoring Reports 3, 5 and 7). Ozone concentrations at Site 3 were usually lower than at Site 1 -- typically the Site 3 concentration would be slightly lower during the day and much lower at night.

F. Particulates

1. Objectives

The objective of atmospheric particulate monitoring is to establish the natural background concentration and the effects of construction in the modular development phase of tract operations.

2. Methods

The methods followed for collection of total suspended particulate data were described in RBOSC MDP Monitoring Report 8.

3. Results and Discussion

Table 2-2 presents the geometric mean, and maximum and minimum concentrations of total suspended particulates (TSP) measured at the three sites during the monitoring period. The maximum TSP concentrations during this period were 41 $\mu g/m^3$ at Site 1, 49 $\mu g/m^3$ at Site 2, and 57 $\mu g/m^3$ at Site 3, which are well below the applicable NAAQS. Generally, higher values occurred simultaneously at all stations (Appendix 2-1.2).

2.2 METEOROLOGY

Meteorological parameters are monitored to provide information on the general climate of Tract C-a and to provide a basis for estimating the potential impact of emissions that could result from tract development and operation. Three meteorological sites have been in operation during the MDP (Table 2-1). Meteorological data recorded during the reporting period are presented in Appendix 2-2.

A. Temperature and Stability

1. Objectives

Ambient air temperature provides basic information on monthly and year-to-year variability of climatic conditions at the C-a tract. The vertical temperature differential within the lowest layers of the atmosphere can be utilized to determine the stability of the atmosphere. The stability has a profound effect on the dispersion of emissions into the atmosphere that may occur as a result of tract development and operation.

2. Methods

The methods followed for collection of temperature data were described in RBOSC MDP Monitoring Report 3.

3. Results and Discussion

Temperatures at the site had a large range during this data period, which is characteristic of continental climates. The temperature range during this six-month reporting period at the Site 1 10 m level was -19.9 to 21.3C at the Site 1 60 m level, -19.7 to 20.6C; at the Site 2 10 m level -10.3 to 21.5C; and at the Site 3 10 m level -22.0 to 23.5C. The temperature data at Site 3 show the influence of the gulch in increasing the temperature range (Appendices 2-2.1 and 2-2.2).

B. Dewpoint

1. Objectives

Dewpoint data, collected since late July 1978, are used in the evaluation of potential cooling system alternatives. The data are more directly useable than relative humidity data, which had been collected onsite for the same purposes during the baseline period and from December 1977 to late July 1978. Relative humidity can be determined from concurrent dewpoint and temperature measurements.

2. Methods

The methods followed for collection of dewpoint data were described in RBOSC MDP Monitoring Report 3.

3. Results and Discussion

Generally, low dewpoints were recorded during this period, as expected in a semi-arid climate. Dewpoints ranged from a low of -26.1 to a high of -7.3C (Appendix 2-2.1).

C. Wind Speed and Wind Direction

1. Objectives

The wind speed and wind direction influence atmospheric dispersion. Measurement of the frequency of occurrence of wind speed and wind direction classes can be used in interpreting air quality data.

2. Methods

The methods followed for collection of wind data were described in RBOSC MDP Monitoring Report 3.

3. Results and Discussion

Westerly winds prevailed at Sites 1 and 2 during the period. At Site 3, there was a strong tendency for the wind to be oriented along the axis of the gulch (southwest or northeast). See Appendices 2-2.1 and 2-2.2.

D. Precipitation

1. Objectives

Precipitation is recorded to provide data on the scavenging effects of rain and snowfall on air quality. The moisture content of the ground surface is important in plant growth and revegetation efforts, and may also influence wind erosion.

2. Methods

The methods followed for collection of these data were described in RBOSC MDP Report 2.

3. Results and Discussion

Precipitation data from the several measuring methods are included in the data appendix (Appendix 2-2.3). There are differences in the reported precipitation between the gauges installed at each site but there is good agreement among sites for a particular gauge type. Although the wedge gauges generally have better exposure, the weighing bucket gauges have better collection and retention efficiency and are therefore considered more accurate. The weighing bucket gauges at Sites 1 and 2 recorded 4.25 and 5.68 inches of precipitation, respectively, during the six-month data period. These are considered the most representative precipitation data at the site.

E. Solar Radiation

1. Objective

Solar radiation is monitored to acquire a data base useful in interpreting air quality data.

2. Methods

The methods followed for collection of solar radiation data were described in RBOSC MDP Monitoring Report 3.

3. Results and Discussion

The majority of the days during the monitoring period were clear with high solar radiation values, typical of a high altitude site with a dry climate. Values are reported in Appendix 2-2.1.

2.3 VISIBILITY

Documentation of visibility in the Piceance Creek Basin is a cooperative study conducted by the Rio Blanco Oil Shale Company and the Cathedral Bluffs Shale Oil Venture.

1. Objectives

The objectives of this program are to document the visibility in the area of the Piceance Creek Basin and identify trends or variations in visibility which may be evident during the monitoring program. The results of this program will provide visibility data against which past and future data may be compared and with which concurrent meteorological and air quality data may be incorporated for further evaluation and consideration.

2. Methods

Two methods are being employed in the documentation of basin-wide visibility during the Spring study. A photometric method incorporates techniques identical to those utilized during the baseline study and described in RBOSC MDP Monitoring Report 1. A second method which was first used in 1979 uses a telephotometer to derive visual ranges. The results of the two methods will be compared at the end of the study. Data are being collected every sixth day along four views during the Spring season. The Fall study has not been finalized as yet.

3. Results and Discussion

The Spring visibility study was conducted during May and June of 1981. Since the study was not completed during the period covered by this report, the results will be presented along with the Fall visibility study in the year-end report.

2.4 NOISE

Development activities on Tract C-a will result in increased noise levels in the area. In order to assess the potential effects of these increased noise levels, it will be necessary to identify the sources of the noise and the intensity of noise levels at various distances from these sources. The RBOSC noise survey is designed to provide these data.

1. Objectives

Regulations regarding allowable noise levels have been promulgated for the safety and well being of humans. None of the existing regulations apply to effects of noise on wildlife, although some research has been conducted in this area (EPA 1971, Effects of noise on wildlife and other animals, Memphis State University). The objectives of the environmental noise program are to:

- Provide a data base on relative noise levels at various distances from sources on the tract

- Provide data for use by wildlife biologists in assessing the overall impacts of tract development on wildlife behavior and use of the study area.

2. Methods

In order to acquire the necessary noise level measurements, sound level readings are taken once each quarter at strategic monitoring sites around the mine development area. During the period of study, two noise surveys were made. Noise measurements were taken at 16 monitoring sites on February 13, and on May 18. The monitoring sites were arranged in a configuration of concentric circles at various distances from the area of mine activity out to the borders of Tract C-a, as described in Table 2-3.

One other reading was taken in close proximity to the headframe for an indication of highest noise production.

Table 2-3. Locations of Environmental Noise Monitoring Sites, Tract C-a

Site Number	Locations/Descriptions
1	Top of knoll N.E. of Hunting Camp, E. of road down to Corral Gulch
2	South side of site access road, 20 ft S.W. of "Hill" signs
3	N.E. corner of intersection of Airplane Ridge Road and tank access road
4	South side of Corral Gulch Road at fence corner slightly past power line
5	100 ft S.E. from well CE-707, on line between survey point and Headframe
6	Northwest of Well TO-2 outside of fence, 10 ft W. of survey point
7	North side of Corral Gulch Road at Well GS-4-5 on top of road cut
8	West side of Wolf Ridge road on small knoll directly across from entrance to Well GS-6 and trailer camp
9	North side of fenced area at Well TO-1 near entrance
10	South side of Box Elder Gulch Road at N.E. fence corners for Well AM-3
11	North side of Corral Gulch Road at turn-around area, across from U.S.G.S. stream gauging station
12	South side of road to Met. Site #1, 0.1 mile from power line crossing and S.W. corner of well GS-1
13	North side of Wolf Ridge Road, N.E. corner of road to Well GS-10
14	South side of Wolf Ridge Road at Tract C-a boundary line
15	East side of road, 0.15 mile north of Met. Site #2 access road
16	North of County Road 24 at intersection of Wolf Ridge Road
A	Approximately 30 ft east of main shaft Headframe

The methods followed in the collection of noise data were described in RBOSC MDP Monitoring Report 3.

3. Results and Discussion

Sound level readings taken during the two surveys are shown in Tables 2-4 and 2-5. The highest average decibel level was 69 dBA in the February survey and 73 dBA in the May survey. Both of these readings were obtained at the monitoring site near the headframe, which is the focal point of onsite activity. Background noise levels were on the order of 22-35 dBA and were reached when readings were taken at distances greater than about one mile from mining activities. These same general decibel levels were found in readings taken on site boundaries. Exceptions to background noise were noted when there was aircraft passing overhead, vehicular traffic in the area or some other activity (e.g. drilling) near the monitoring site.

Noise levels taken during these two surveys were generally comparable to those taken during the earlier noise surveys. The potential for wildlife disturbances due to noise of this magnitude is anticipated to be small.

Table 2-4. Environmental Sound Level Measurements Tract C-a, February 13, 1981

Site	Time	Wind	Sound Level Measurements (dBA, Slow Response) (20 sec range)					Sound Level dBA Range	Sound Level dBA Average	Remarks
			1	2	3	4	5			
A	0900	Calm	68-72	67-72	67-69	67-69	67-69	67-72	69	Process area, tract noise
1	0911	Calm	34-36	35-40	35-38	36-39	35-38	34-40	37	Process area noise
2	1204	1-4/E	<30-39	<30	<30	<30-35	<30-39	<30-39	--	Traffic noise
3	1157	0-2/S	34-37	33-37	35-40	34-38	34-42	33-42	36	Process area, jet noise
4	0955	Calm	<30	<30	<30	<30	<30	--	--	
5	0939	Calm	<30	<30	<30	<30	<30	--	--	
6	0946	Calm	30-40	30-39	30-38	30-37	31-36	30-40	34	Construction activity, jet noise, birds
7	1014	1-4/E	40-70	<30	30-35	<30	<30	<30-70	--	Process area, truck noise
8	1027	Calm	<30	<30	<30	<30	<30	--	--	
9	1140	Calm	<30	<30	<30	<30	<30	--	--	
10	1146	Calm	<30	<30	<30	<30	<30	--	--	
11	1004	Calm	<30	<30	<30	<30	<30	--	--	
12	0933	0-3/E	<30	<30	<30	<30	<30	--	--	
13	1035	0-2/E	30-32	31-33	30-34	31-33	30-33	30-34	32	
14	1043	0-2/SE	<30	<30	<30	<30	<30	--	--	
15	1050	Calm	<30	<30	<30	<30	<30	--	--	
16	1021	1-4/E	<30-32	<30	<30	<30	<30-32	--	--	
A	1210	1-3/E	67-70	67-70	67-69	67-69	67-70	67-70	68	Process area, traffic noise

Table 2-5. Environmental Sound Level Measurements Tract C-a, May 18, 1981

Site	Time	Wind	Sound Level Measurements (dBA, Slow Response) (20 sec range) 1	2	3	4	5	Sound Level dBA Range	Sound Level dBA Average	Remarks
A	1043	0-3/E	69-71	69-72	68-70	68-71	69-71	68-72	70	Process area noise
1	1051	0-3/E	35-37	34-37	35-37	36-39	35-38	34-39	36	Process area, traffic noise
2	1336	Calm	35-40	36-40	38-40	37-41	36-39	35-41	38	Process area, light construction activity
3	1329	Calm	39-42	39-44	40-42	41-43	39-42	39-44	41	Process area noise
4	1145	0-5/E	40-51	40-52	40-50	37-47	37-44	37-52	44	Process area noise, birds
5	1114	0-4/NE	30-36	30-38	31-36	31-35	31-38	30-38	34	Process area noise
6	1125	0-6/E	<30-35	30-38	<30-37	<30-38	30-36	<30-38	--	Process area noise, birds
7	1152	0-6/E	37-44	36-42	36-42	40-46	37-45	36-46	40	Process are, traffic noise, birds
8	1205	0-2/NE	<30-47	<30-39	<30-45	<30-42	<30-40	<30-47	--	Process area noise, but primarily birds
9	1305	Calm	<30	<30	<30	<30-37	<30	--	--	
10	1317	Calm	<30	<30	<30	<30	<30	--	--	
11	1137	0-2/E	<30-43	<30-40	<30-40	<30-39	<30-39	<30-43	--	Process area noise, birds
12	1107	Calm	38-48	35-49	34-47	35-43	30-35	30-49	39	Process area noise, jets
13	1233	Calm	33-37	33-37	33-37	33-37	33-37	33-37	35	Sun gas drilling activity, birds
14	1240	0-4/E	<30	<30	<30	<30	<30	--	--	
15	1248	0-3/E	<30	<30	<30	<30	<30	--	--	
16	1159	0-5/E	<30	<30-33	<30-39	<30-34	<30-33	<30-39	--	Process area noise, birds
A	1343	0-3/E	72-76	70-74	71-74	72-74	71-75	70-76	73	Process area, traffic noise

2.5 SUMMARY AND CONCLUSIONS

Air quality and meteorological data were collected during the six-month reporting period. No unusual events or violations of National Ambient Air Quality Standards occurred. All of the air quality parameters were below the threshold of detection most of the time, with the exception of ozone and particulates. Ozone concentrations ranged from 0.021 to 0.070 ppm at Site 1, and from 0.003 to 0.066 ppm at Site 3. Total suspended particulate concentrations ranged from 4 to 49 $\mu g/m^3$ at the two sites measuring generally background particulate levels (Sites 1 and 2) and from 6 to 57 $\mu g/m^3$ at the site located in Corral Gulch (Site 3), which is often downwind of tract activities. These values are similar to those found in earlier mid-year reports (MDP Monitoring Reports 2 and 4).

No significant changes have been detected in the meteorological data collected during the six-month data period.

A Spring visibility study using both the traditional photometric method and a telephotometer to measure visual range has been initiated but was not completed during this reporting period. The results of the Spring study will be reported in the year-end report, along with the results of the Fall study.

Two noise surveys were taken during the reporting period. During the February survey, sound level averages on the tract ranged from less than 30 to 42 dBA, except when traffic passed the sampling point or near the main construction area (adjacent to headframe). The average sound level in the main construction are averaged 69 dBA. During the May survey, sound level averages ranged from less than 30 to 52 dBA, except for an average of 72 dBA near the main construction area.

SECTION 3

TERRESTRIAL STUDIES

The Terrestrial Studies MDP Monitoring Program is designed to detect and evaluate those impacts affecting the floral or faunal components of the terrestrial ecosystems on or near Tract C-a.

The Tract C-a terrestrial studies are geared to seasonal cycles of the ecosystem components; therefore, sampling is conducted during those seasons when the appropriate measurements can be made (Table 3-1). The study period reported herein is December 1980 through May 1981, and includes the results of studies on browse condition and utilization, Spring mule deer pellet group counts, mule deer road kills and feral horse abundance. Vegetation stress (based on color infrared (CIR) photography), vegetation type mapping, phyto-sociological, range productivity and utilization, small mammal, avifauna and Fall mule deer studies will be reported in the MDP year-end report. Figure 3-1 illustrates the locations of terrestrial monitoring sites. Opportunistic observations of important events and unscheduled special studies are included in MDP monitoring reports as they occur.

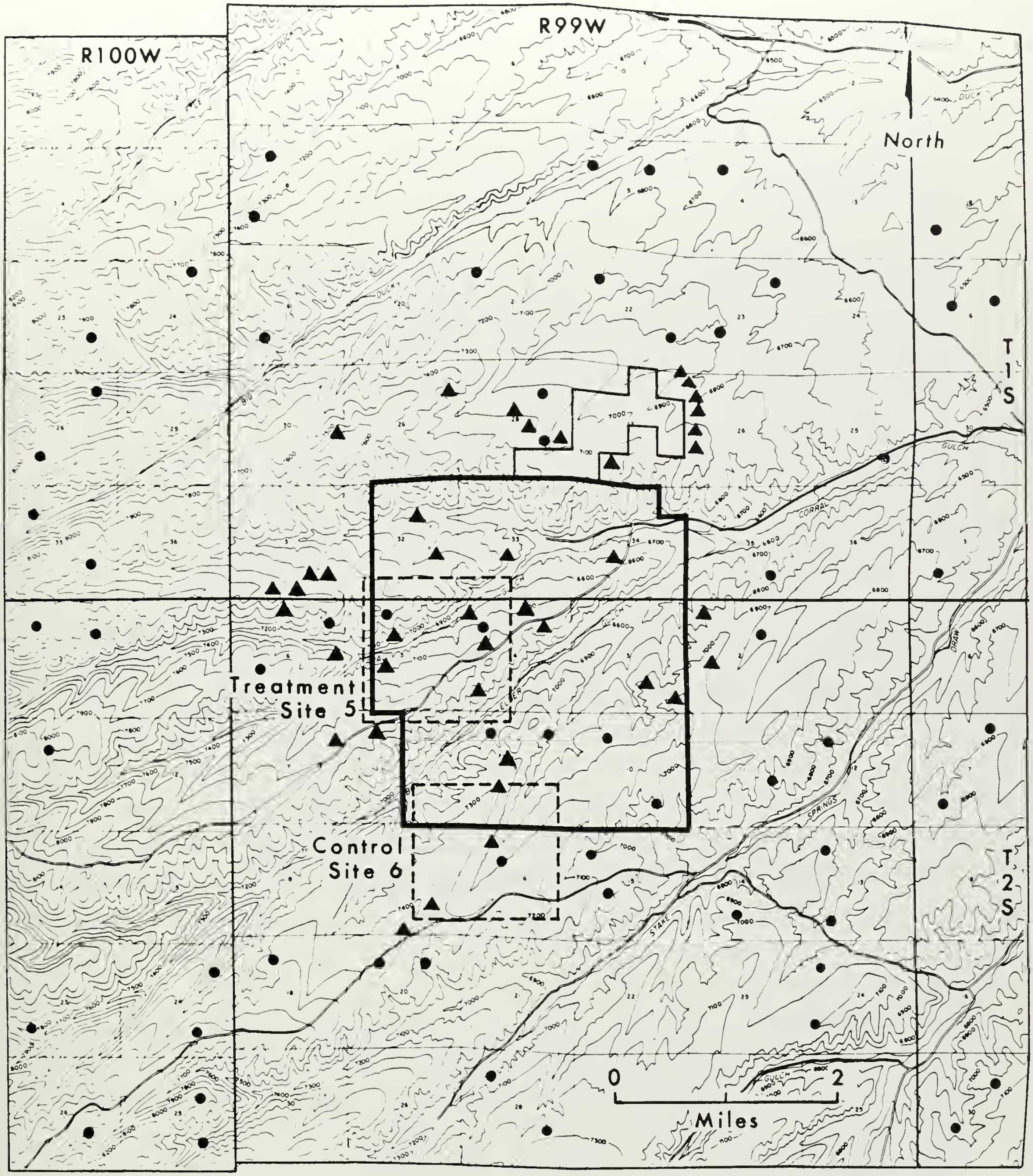
Terrestrial data presented in this report were collected according to the methods described in the Modular Development Phase Environmental Monitoring Program Scope of Work, Revision 6.1 (RBOSC 1981a). All data were verified in compliance with RBOSC quality control procedures, including supervisory verification of field data sheets, laboratory analysis and data management procedures. Documentation supporting these quality control activities is maintained in the RBOSC Quality Assurance files.

Table 3-1. Terrestrial Studies Monitoring Schedule

Parameter	Location[1]	Start Date	Frequency
Vegetation Mapping	Tract C-a & 5-mile Perimeter	August 1978[2]	Every 3rd year
Vegetation Stress	Anticipated impact areas	June-July 1979	Annually
Vegetation Phytosociological Studies	See Map 2	May-June 1979	Once/3-yr period Rotation Basis
Range Productivity & Utilization	See Map 2	April 1978	Annually (in Sept.)
Browse Condition & Utilization	See Map 2	May 1978	Annually
Small Mammals	See Map 2	May-June 1979	Annually
Avifauna Studies	See Map 2	May-June 1979	Annually
Mule Deer Density Studies	See Map 2	Sept. 1977	Annually
Mule Deer - Road Kill Studies	County Road 24	Feb. 1979	Daily During Peak Migrations
Feral Horse Abundance	Tract C-a & 3-mile Perimeter	Jan. 1978	Annually

[1] Locations of sampling sites (Map 2) were presented in RBOSC MDP Monitoring Report 5 (RBOSC 1980a).

[2] 1978 aerial photography was accomplished in August; however subsequent flights will be scheduled for June-July.



● Mule Deer Pellet Group Sample Unit

▲ Range-Browse, Productivity & Utilization Study Site

[ ] Intensive Study Sites

Figure 3-1. Terrestrial Ecology Monitoring Sites.

3.1 VEGETATION, RANGE AND BROWSE

A. Vegetation Mapping and Stress

1. Objectives

Construction and operation of Tract C-a facilities may affect the local distribution and/or condition of vegetation types. The vegetation studies are designed to monitor the distribution of vegetation on Tract C-a and adjacent areas to determine large-scale changes resulting from MDP development, to identify stress conditions, and to document changes over time in the plant communities. Documentation of plant community distribution and condition is accomplished via color and CIR aerial photography.

2. Methods

Color infrared aerial photographic studies follow methods detailed in RBOSC MDP Monitoring Reports 1 and 4 (RBOSC 1978a, 1979b). For 1981, vegetation type distribution will be assessed using black-and-white rather than color aerial photography (scale approximately 1"=2000'). Black-and-white photography was used because it will be amenable to analysis for vegetation type mapping as well as computer modeling of potential shale disposal sites. Aerial photography was flown during June 1981 and results will be presented in the year-end report (MDP Monitoring Report 9).

B. Phytosociological Studies

1. Objectives

The objective of the phytosociological studies is to monitor species composition and coverage in the major vegetation types which may be affected by Tract C-a development. These studies provide quantitative data which complement information on distribution of major habitat types and provide continuity with similar data collected during the baseline period.

2. Methods

Phytosociological data are collected using techniques detailed in RBOSC MDP Monitoring Reports 5 and 7 (RBOSC 1980, 1981b). The 1981 phytosociological studies were conducted during June 1981 and results will be presented in MDP Monitoring Report 9.

C. Range Productivity and Utilization

1. Objectives

Tract C-a MDP activities may affect range conditions on and near the tract by altering use patterns of deer, cattle, and feral horse populations, thus changing grazing pressure. The range studies are designed to provide information which can be used to compare range productivity and utilization before and during modular development. Because activities associated with tract development are confined primarily to the mine process area, impacts on range conditions are projected to be localized. Therefore, range studies focus on areas of Tract C-a and vicinity that are adjacent to MDP activities, and that previously were used for grazing.

2. Methods

The methods for collection of range data were described in RBOSC MDP Monitoring Reports 1, 2 and 3 and are not repeated herein (RBOSC 1978a, 1978b, 1979a).

Range cage positions were established between April 27 and May 8, 1981. Cages were placed four meters to the right of transect location stakes (as sighted along a line from plot 1 toward plot 10).

A total of 10 new range production and utilization transects was established during the reporting period (5 in upland sagebrush and 5 in the pinyon-juniper vegetation types). These sites correspond to 10 new browse condition transects and are located adjacent to the DOW exchange property (Figure 3-1).

Range production and utilization sampling is scheduled for August-September 1981 and results will be included in the year-end report.

D. Browse

1. Objectives

Tract C-a development will reduce browse availability and therefore may affect the distribution of deer in the vicinity of Tract C-a. The browse condition and utilization studies are designed to provide browse use information for areas adjacent to Tract C-a development.

2. Methods

The methods for collection of browse data were described in RBOSC MDP Monitoring Reports 1 and 2 (RBOSC 1978a, 1978b). Transect numbers and locations are the same as those for range productivity studies, with 10 new sites being added during the reporting period (Figure 3-1).

3. Results and Discussion

Data obtained during the 1981 sampling period are summarized in Table 3-2 and presented in their entirety in Appendix 3-1.1.

a. Mixed Brush - The 1981 data set for the mixed brush vegetation type includes nine transects. Analyses of 1980 range production data, as well as a reevaluation of the general site conditions and species composition, for transect 6 indicated that this transect would be categorized more appropriately in the pinyon-juniper vegetation type. Consequently, only 225 individual shrubs were sampled, which represents a reduction of 11 serviceberry (*Amelanchier utahensis*), two snowberry (*Symphoricarpos oreophilus*), 10 mountain mahagany (*Cercocarpos montanus*) and two pinyon pine (*Pinus edulis*) individuals from those sampled during previous years. Subsequent analyses will reflect this change for data sets from all years.

Serviceberry exhibited the highest leader utilization (7 percent average for 111 living individuals) whereas pinyon pine had the lowest (<1 percent average for 4 living individuals) (Table 3-2). Utilization for sagebrush, snowberry, and mountain mahogany was similar to that for serviceberry (6, 5, and 5 percent, respectively). These data indicate that browse use increased from 1980 to 1981 for serviceberry (3.3 to 7 percent), sagebrush (Artemisia tridentata) (5.2 to 6 percent) and snowberry (0.6 to 5 percent), and decreased for mountain mahogany (21.1 to 5 percent) and pinyon pine (5.8 to <1 percent). These changes may be a result of the removal of transect 6 from the mixed brush type as well as variation in use by deer.

The weighted average utilization for all individuals sampled within the mixed brush vegetation type was 5 percent during 1981 (Table 3-3). This represents a slight increase in overall usage from 1980 to 1981; however, usage is generally lower than for the 1976-1979 sampling periods. Based on Cole's (1963) classification levels for use of vigorous, mature plants on winter range, all of the species sampled were judged to have "allowable" leader use rates for mild winter conditions. This classification is the same as that exhibited during the 1980 reporting period.

The distribution of individual shrubs by form class has changed as a result of the transfer of transect 6 from the mixed brush to the pinyon-juniper vegetation type. The increased percentage of dead mountain mahogany plants is an example of this phenomenon. However, the majority of individuals remain in form classes 1, 2 and 4.

The range condition ratings, as based on the percentage of individuals in the decadent age classification (Table 3-2), for species sampled in the mixed brush vegetation type are "excellent" for pinyon pine and mountain mahogany, and "poor" for serviceberry, sagebrush and snowberry (Cole 1963). Corresponding ratings based on the percentage of severly hedged individuals indicate that all species sampled within the mixed brush vegetation type would receive an "excellent" condition rating. Because the same individual plants are sampled each year, the condition rating based on hedging reflects the change in browsing pressure more accurately than does the rating based on age classification. The 1981 ratings based on hedging class indicate that

Table 3-6. Condition of Important Browse Species Sampled in Three Vegetation Types Ouring May 1979 in the Vicinity of RBOSC Oil Shale Tract C-a.

Habitat Type	Species	Number Plants Sampled	Average Util. (%)	Average Avail. (%)	Form Class (%) 1	2	3	4	5	6	7	8	Age Class (%) Seedling	Young	Mature	Oeca-dent	Hedging Class (%) Light	Moderate	Severe
MB	Serviceberry	128	9.0	78.4	38	12	6	13	16	7	-	8	2	6	53	38	53	30	17
	Sagebrush	61	5.0	81.1	31	23	-	10	16	10	-	10	-	-	66	34	45	45	9
	Snowberry	41	4.5	62.9	34	2	-	27	22	5	5	5	2	10	34	54	64	31	5
	Mountain Mahogany	14	35.4	83.8	7	36	14	7	7	14	-	14	14	-	57	29	17	50	33
	Pinyon Pine	6	7.8	100.0	50	33	-	17	-	-	-	-	-	-	100	-	67	33	-
PJ	Sagebrush	103	11.7	68.9	15	12	7	15	17	22	-	13	1	-	41	58	32	33	34
	Pinyon Pine	50	6.5	65.2	28	8	10	20	12	-	20	2	6	6	80	8	61	29	10
	Juniper	37	0.1	42.8	24	-	-	24	16	3	19	14	-	3	73	24	75	22	3
	Bitterbrush	36	23.1	64.6	3	17	8	3	36	25	-	8	-	-	39	61	6	58	36
	Mountain Mahogany	17	55.9	69.5	-	-	12	-	6	82	-	-	-	-	65	35	-	-	100
	Snowberry	4	66.7	34.0	-	25	50	-	-	-	-	25	-	-	75	25	-	33	67
	Serviceberry	3	29.0	23.3	-	33	-	33	-	33	-	-	-	-	33	67	33	33	33
SB	Sagebrush	235	3.9	78.6	17	14	3	12	14	16	-	23	-	-	49	51	37	37	26
	Serviceberry	11	3.3	85.6	45	18	-	18	-	-	-	18	-	18	55	27	89	11	-
	Snowberry	4	0.0	28.8	-	-	25	-	75	-	-	-	-	-	25	75	-	75	25

MB = Mixed Brush
PJ = Pinyon-Juniper
SB = Sagebrush

Form Classes

1 All available, little or no hedging
2 All available, moderately hedged
3 All available, severely hedged
4 Partially available, little or no hedging
5 Partially available, moderately hedged
6 Partially available, severely hedged
7 Unavailable
8 Oead

Table 3-3. Comparison of Weighted Average Utilization (in percent) in Three Vegetation Types During April 1976, April 1977, May 1978, May 1979, May 1980, and May 1981 on and Near Tract C-a[1/]

Vegetation Type	April 1976	April 1977	May 1978	May 1979	May 1980	May 1981
Mixed Brush	12	17	7	8	4	5
Pinyon-Juniper	27	24	31	15	10	8
Sagebrush		6	25	4	1	4

1/

$$\frac{\sum_{i=1}^{j} (\bar{x}_i n)}{\sum_{i=1}^{N} N_{ij}} = W\bar{x}_{ij}$$

Where $W\bar{x}$ is the weighted average utilization, N = 250 for 1976-1980, and 255, 400 and 375 for MB, PJ and SB, respectively during 1981 the condition of serviceberry and mountain mahogany has improved from that exhibited during 1980, while the ratings for pinyon pine, sagebrush and snowberry have remained the same. These changes may result more from the removal of transect 6 from the data set than from actual changes in browsing pressure.

b. Pinyon-juniper - With the addition of five new transects and the transfer of transect 6 to this vegetation type, a total of 400 individual shrubs was sampled during the 1981 reporting period. Bitterbrush (*Purshia tridentata*) and mountain mahogany exhibited the greatest leader utilization (44 and 36 percent, respectively). Twenty-eight living individuals were sampled for each of these species. Sagebrush was the most abundant species sampled (157 living individuals) and exhibited leader useage which averaged six percent. Both pinyon pine and serviceberry had three percent leader use (60 and 12 living individuals, respectively) while leader use was less than one percent for the 54 junipers (*Juniperus osteosperma*) sampled. No leader use was noted for the five living snowberry plants encountered on the 16 transects.

Weighted average utilization based on all individuals sampled in the pinyon-juniper vegetation type was eight percent (Table 3-3). This represents a slight reduction in utilization from the 10 percent recorded during 1980. Reduced use may be a result of the mild winter conditions which allowed for increased use of other vegetation types. It also should be noted that the increased sample size during 1981 has influenced these data. Nevertheless, 1981 use values would be deemed "acceptable" for average winters in the case of bitterbrush and mountain mahogany (Cole 1963). All other species sampled exhibited "acceptable" leader use for mild winter conditions.

With increased sample size the distribution of individuals by form class changed slightly. The percentage of dead plants (form class 8) increased for sagebrush, juniper, pinyon pine, and serviceberry, remained the same for mountain mahogany, and decreased for snowberry and bitterbrush. Distribution among the other form classes was variable; however, form classes 1, 4, and 5 seem to be the most prominent (Table 3-2).

Range condition ratings based on age distribution were "poor" for sagebrush, juniper, mountain mahogany, serviceberry and snowberry. Pinyon pine condition was judged to be "excellent" while that for bitterbrush was "very poor" (Cole 1963). Mountain mahogany and serviceberry also would have "poor" conditions ratings based on the percentage of severely hedged shrubs (50 and 42 percent, respectively) (Table 3-2). The remaining species received more favorable ratings based on hedging classification than on age distribtuion. Juniper, pinyon pine and snowberry had "excellent" ratings, sagebrush exhibited "good" condition, and bitterbrush was judged to have a "fair" condition rating. For most species, ratings based on hedging classification show a marked improvement over those experienced during 1980. This may be due in part to decreased grazing pressure, but the majority of change probably results from the increase in sample size. If this is true, one might suspect that shrubs in the pinyon-juniper stands on and adjacent to the RBOSC off-tract property to the north of Tract C-a are not as heavily utilized as are similar habitats on Tract C-a. This supposition will be considered in analyses presented is the year-end monitoring report.

c. Sagebrush - Fifteen transects (375 individual shrubs) were sampled during 1981, with 122 sagebrush and three junipers being added to the data set. Serviceberry was browsed most heavily with the nine living shrubs averaging 15 percent leader use. The 275 living sagebrush individuals averaged five percent leader use. No leader use was recorded for juniper or pinyon pine, and snowberry had only one percent use for four living individuals.

Weighted average utilization for all shrubs sampled increased from one percent during 1980 to four percent for the 1981 reporting period (Table 3-3). This increase results primarily from increased leader use for sagebrush (1.1 vs. 5 percent for 1980 and 1981, respectively) and serviceberry (0.6 vs. 15 percent for 1980 and 1981, respectively). These use values are well within the "allowable" range which Cole (1963) suggests for mild winters. The reasons for increased utilization when little or no change in the size of the deer herd was noted are not entirely clear. It is possible that individual shrubs of sagebrush and serviceberry species along the new transects are browsed more heavily than those of the original 10 transects.

Further analysis and/or sampling should clarify this supposition, and these considerations will be addressed in subsequent reports.

Increased sample size did not influence form class distribution to a large degree. The majority of individuals continue to be categorized in form classes 1, 4 and 5. There was a three percent increase in dead (form class 8) sagebrush plants associated with an increase of 52 percent in the number of sagebrush plants sampled. The corresponding increase of dead sagebrush associated with the new transects within the pinyon-juniper type was 12 percent.

The range condition ratings for sagebrush and snowberry were "very poor" based on the percentage of plants in the decadent age class. The corresponding rating for serviceberry was "fair" while both juniper and pinyon pine exhibited "excellent" range condition ratings. These values are similar to those evidenced during the 1980 reporting period. However, based on hedging class distribution, sagebrush, snowberry, juniper, and pinyon pine had "excellent" range condition ratings (Cole, 1963). Serviceberry had an "excellent" rating in 1980 but was rated as "good" during the 1981 reporting period.

3.2 FAUNA

A. Small Mammal Studies

1. Objectives

The RBOSC small mammal program is designed to determine species presence and habitat affinity and to provide indices of relative abundance in important control and treatment habitats. The objectives of the small mammal program are to determine the presence and relative abundance (captures/ 100 trap nights) of small mammals in sagebrush and pinyon-juniper habitats in control and treatment areas, and to compare any changes over time within these habitats for each area.

2. Methods

The methods followed for the collection of these data were described in RBOSC MDP Monitoring Report 5 (RBOSC 1980a).

3. Results and Discussion

The data collection period for small mammal studies was June 1981. Results of those studies will be discussed in the year-end report.

B. Avifauna Studies

1. Objectives

The RBOSC avifauna program is designed to determine species composition and relative abundance in important control and treatment habitats (same habitats as monitored for small mammals).

The objectives of the avifauna program are to determine species composition and relative abundance of birds in pinyon-juniper and sagebrush habitats in control and treatment areas, and to compare any changes over time within these habitats for each area. The habitats monitored are those sampled for small mammals.

2. Methods

The methods followed for the collection of these data were described in RBOSC MDP Monitoring Report 5 (RBOSC 1980a).

3. Results and Discussion

The data collection period for avifauna studies was June 1981 and results of those studies will be discussed in the year-end report.

C. Mule Deer Density

1. Objectives

Mule deer are the most important game species in Colorado in terms of recreational use and money expended by hunters. The Piceance Creek Basin mule deer herd is one of the largest migratory mule deer herds in North America. Tract C-a is within the Piceance Creek Basin and Colorado Division of Wildlife's (CDOW) Game Management Unit 22.

Moderate numbers of mule deer occur on Tract C-a during fall and spring migration periods and during average winters; at other times mule deer are relatively uncommon on the tract. Consideration of the possible effects of Tract C-a oil shale development on mule deer is an integral part of RBOSC's Fish and Wildlife Management Plan.

The objectives of RBOSC's mule deer monitoring program are to obtain an index of mule deer density in a 9 x 9 mile (81 sq mile) study area centered on Tract C-a, to compare indices of mule deer density from the study area with those from the Game Management Unit 22, and, if possible, to compare differences in mule deer densities within various portions of the study area.

2. Methods

The methods followed for the collection of these data were described in RBOSC MDP Monitoring Report 1 (RBOSC 1978a).

3. Results and Discussion

Mule deer pellet groups were counted during May 1981 in established plots in the 63 quarter section (160 acre) sample units comprising the Tract C-a study area. Pellet group information from this sample period (Appendix 3-2.1) is summarized in Table 3-4. Detailed analyses of that information will be reported in the 1981 MDP year-end report.

Based on Spring 1981 data (Table 3-4), it appears that the deer use of the area around Tract C-a during the 1980-81 winter was lower than that reported for the three previous winters. The average number of deer per square mile was 24.4. The winter of 1979-80 was very mild with virtually no snow pack, and deer were able to feed at high elevations normally used for summer range. The RBOSC study area is considered deer winter range and was not heavily used by deer in 1980-81. Therefore, the amount of deer use of the RBOSC study area last winter probably does not represent the size of the deer herd but rather a limited period of use.

D. Mule Deer Road Kill Study

1. Objectives

The Piceance Creek Basin is currently the center of a great deal of energy development activity including oil shale and natural gas. This increased activity has resulted in increased traffic across mule deer migration routes. The CDOW and RBOSC are interested in obtaining data relative to the mortality of mule deer as a result of vehicle-deer collisions.

The objective of this program is to provide data on mule deer mortality along County Road 24 from Piceance Creek to Tract C-a for compilation and use by the CDOW.

Table 3-4. Mule Deer Pellet Groups Counted on RBOSC Tract C-a Study Area, Spring 1981

Block and Sample Unit	Number of Pellet Groups in Sample Unit	Total Number of Pellet Groups in Block	Average Number of Groups Per Sample Unit For Each Block	Average Number of Deer Per Square Mile For Each Block[1/]
1-05	2			
1-11	13			
1-16	12			
1-20	4			
1-23	10			
1-26	4			
1-31	17	62	8.86	49.1
2-05	2			
2-06	1			
2-15	4			
2-17	2			
2-24	4			
2-28	5			
2-34	9	27	3.85	26.1
3-01	1			
3-11	2			
3-14	0			
3-17	1			
3-18	2			
3-19	2			
3-34	9	17	2.43	13.5
4-01	12			
4-08	9			
4-13	6			
4-14	12			
4-18	1			
4-23	6			
4-25	8	54	7.71	42.7
5-08	8			
5-13	7			
5-15	3			
5-27	1			
5-28	3			
5-29	3			
5-36	0	25	3.57	19.8
6-08	13			
6-11	2			
6-14	10			
6-27	4			
6-30	5			
6-32	2			
6-35	5	41	5.86	32.5
7-16	5			
7-17	3			
7-19	2			
7-22	4			
7-28	4			
7-32	1			
7-34	4	23	3.29	18.2
8-03	5			
8-05	3			
8-11	3			
8-13	3			
8-14	2			
8-27	2			
8-34	0	18	2.57	14.2
9-03	0			
9-07	0			
9-09	4			
9-15	0			
9-21	1			
9-30	0			
9-35	5	10	1.43	8.7

[1/] Assuming 180 days in the winter sampling period, presence of deer throughout the period, and 13 pellet groups per deer per day. More detailed analyses per plot are being conducted and will be reported in the year-end report.

2. Methods

The methods followed for the collection of these data were described in RBOSC MDP Monitoring Report 5 (RBOSC 1980a).

3. Results and Discussion

Locations of the 7 deer killed by collisions with vehicles along County Road 24 during the reporting period are shown on Figure 3-2. Most of the collisions occurred in areas with a history of previous vehicle/deer collisions. These sections of County Road 24 with a history of numerous deer kills are posted with caution signs during deer activity seasons.

E. Feral Horse Abundance

1. Objectives

Feral horses occur on and in the vicinity of Tract C-a. These horses are protected under federal law and are under the jurisdiction of the BLM. Feral horses compete with cattle and, to a lesser extent, with wildlife for food and water. The objective of feral horse monitoring studies is to provide qualitative information concerning the status of feral horses in the RBOSC study area (i.e., same area as for mule deer).

2. Methods

The methods followed for the collection of these data were described in RBOSC MDP Monitoring Report 1 (RBOSC 1978a).

3. Results and Discussion

Feral horses on the Tract C-a study area were counted from a helicopter in March 1981. Ten bands of horses totaling 57 individuals were observed in the study area (Figure 3-3). One hundred and twenty horses were observed during the January 1980 count. A discussion of feral horse observations and estimated foal success will be included in the 1981 MDP year-end report.

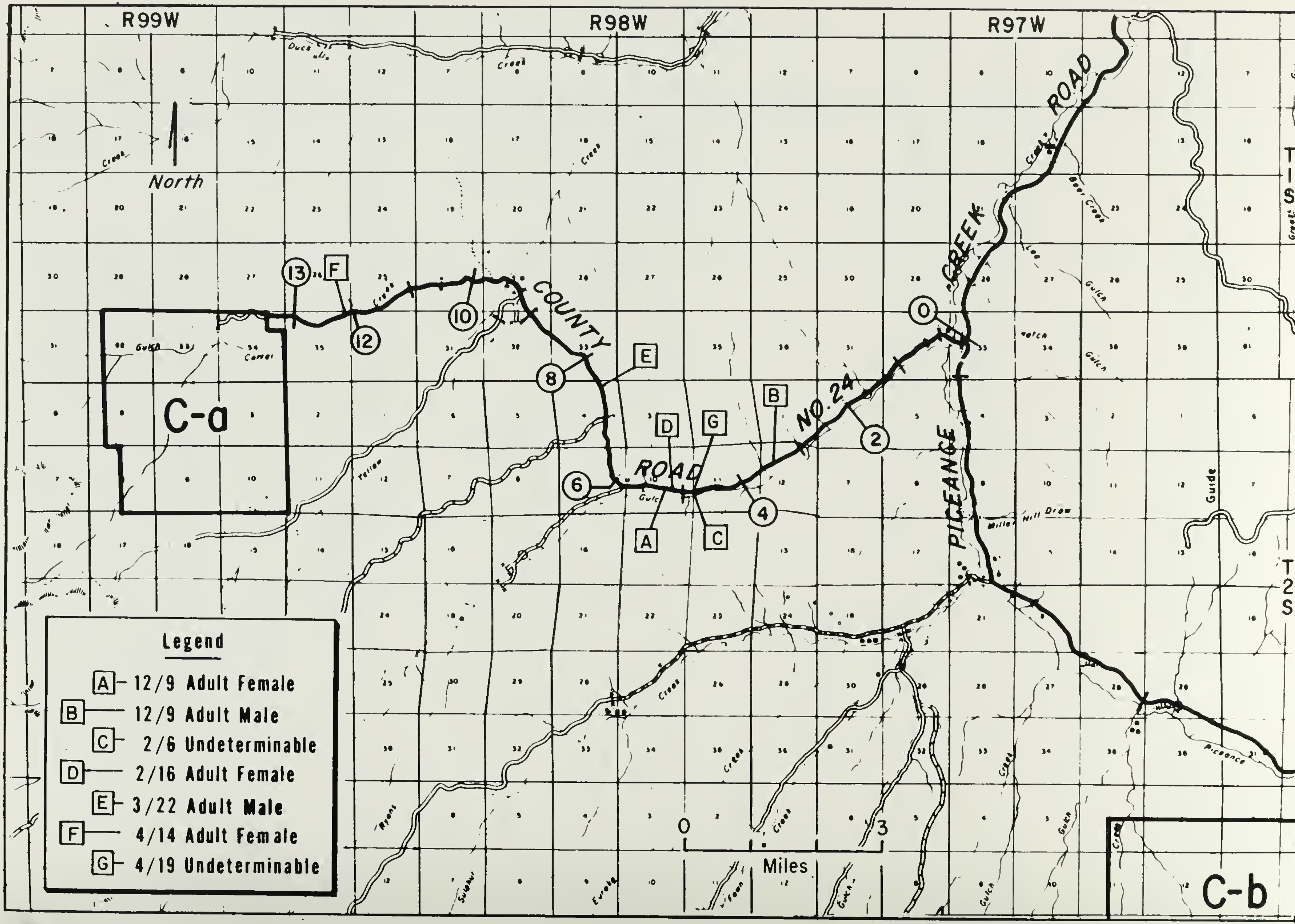
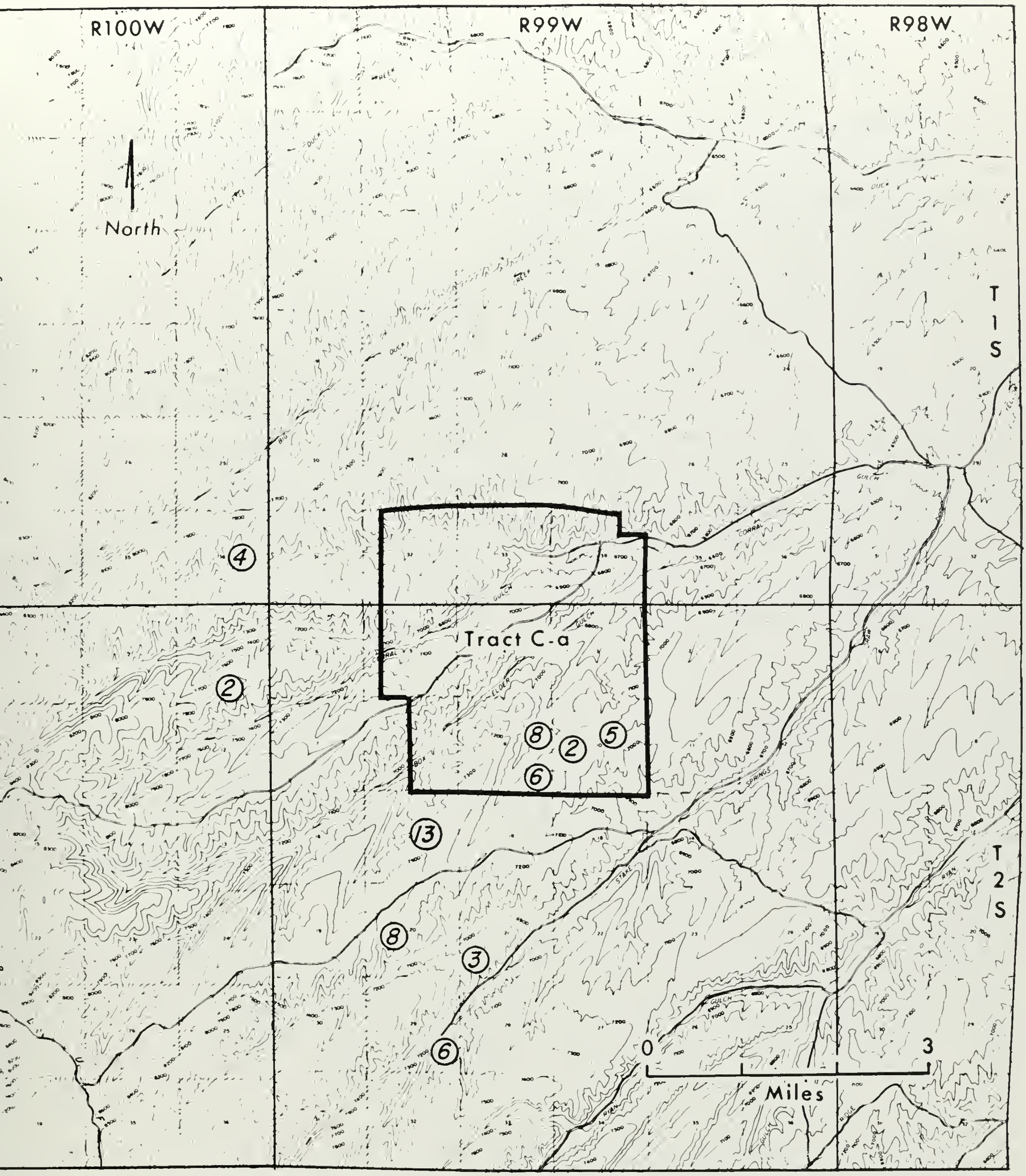


Figure 3-2 Deer killed along Rio Blanco County Road #24, December 1980-May 1981



⑦ Number of Horses in Band and Approx. Location of Band

Figure 3-3: Feral Horses Observed During the March/1981 Aerial Census

F. Threatened, Endangered and Protected Species

Baseline and monitoring studies indicate that Tract C-a does not provide critical habitat for any state or federally endangered wildlife species. No endangered species have been observed on or near Tract C-a during the reporting period nor in recent studies.

3.3 SUMMARY AND CONCLUSIONS

The components of the MDP Terrestrial Monitoring Program examined during the reporting period were browse condition and utilization, mule deer density, mule deer road kills, and feral horse abundance.

Browse studies indicate that the weighted average percent utilization ranged from four percent in the sagebrush to eight percent in the pinyon-juniper vegetation type. Utilization in the mixed brush and sagebrush vegetation types decreased relative to 1980 while that for the pinyon-juniper type increased slightly. Range condition ratings based on age class were similar to those evidenced during 1980; however, there is some indication that range condition is improving. Improvements are evident primarily for ratings based on hedging classification, and are probably due to a combination of variations in browse patterns and increased sample size. Because the RBOSC browse studies are designed to census the same individuals on a yearly basis, one would not expect to find large changes in range condition ratings based on age classification.

The average number of mule deer per square mile using the Tract C-a study area during the winter of 1980-81 (24.4), was approximately 65 percent of the number using that area during the 1978-79 winter. This reduction in mule deer density is probably a result of the mild winter which permitted the deer to stay at elevations higher than those of the study area.

The number of mule deer killed by vehicle collisions along Rio Blanco County Road 24 during the reporting period was 7. Eleven deer killed by collisions with vehicles were found there during the same period the previous year. This lower deer kill figure is probably a result of the reduced number of deer which wintered at the lower elevations of County Road 24.

A total of 57 feral horses in 10 bands was counted in the study area during the winter aerial count. The count was down from the 120 horses observed during the 1980 aerial survey.

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SECTION 4

AQUATIC STUDIES

The MDP Aquatic Monitoring Program is designed to provide information on aquatic aquatic ecosystems in the vicinity of Tract C-a and to identify and measure the potential effects of oil shale development on local aquatic biota. The program was devised following a complete evaluation of data obtained during the RBOSC baseline studies and a determination of the possible impacts of project activities. Criteria for selecting the aquatic parameters measured included ecological importance, sensitivity to environmental changes and ease of sampling. Table 4-1 lists the sampling frequency and the parameters measured at each location.

Six sampling sites are used in the MDP monitoring program (Figure 4-1):

- Station CG-1 at the USGS station in Corral Gulch (east)
- Station YC-1 in Yellow Creek below the confluence of Stake Springs Draw and Corral Gulch
- Station YC-2 in Yellow Creek just below the point where it resurfaces from the alluvium
- Station YC-3 at the USGS gaging station in Yellow Creek
- Station WR-1 and WR-2 near the confluence of Yellow Creek with the White River

Sampling was initiated in October 1977 at Station CG-1, YC-3, WR-1 and WR-2, which were reported previously as Stations 13, 20, 27 and 29, respectively. Two new stations, YC-1 and YC-2, were added in 1981. This report provides the sampling results from April 1981. A brief comparison with the April samples from previous years as well as a discussion of trends and findings are presented. Detailed evaluations of 1981 aquatic monitoring data will be included in the year-end report.

Table 4-1 Aquatic Studies Monitoring Schedule

Parameter	Location	Frequency
ABIOTIC COMPONENTS:		
Physical Measurements	All Stations (see Figure 4.1)	3 times/year (April, July, October)
Total dissolved solids		
Stream velocity and flow		
Turbidity		
Dissolved oxygen		
pH		
Specific conductance		
Depth		
Width		
Stream substrate		
Suspended solids		
Temperature		
Alkalinity		
Basic Water Quality Measurements	All Stations	3 times/year (April, July, October)
Calcium		
Magnesium		
Potassium		
Sodium		
Bicarbonate		
Carbonate		
Chloride		
Nitrate		
Sulfate		
Flouride		
Ammonia		
Total phosphate		
Boron		
Silica (S_iO_2)		
Iron		
Dissolved organic carbon		
Arsenic		
Selenium		
Vanadium		
Molybdenum		
Mercury		
Trace Water Quality	All Stations	Once a year (October)
Aluminum		
Barium		
Beryllium		
Bismuth		

Table 4-1 (continued)

Parameter	Location	Frequency
Bromide		
Cadmium		
Chromium		
Copper		
Gallium		
Germanium		
Iron		
Lead		
Lithium		
Manganese		
Nickel		
Strontium		
Titanium		
Zinc		
Zirconium		
BIOTIC COMPONENTS:		
Periphyton	All Stations	3 times/year (April, July, October)
Species composition		
Relative abundance		
Diversity		
Benthos	All Stations	3 times/year (April, July, October)
Species composition		
Relative abundance		
Diversity		

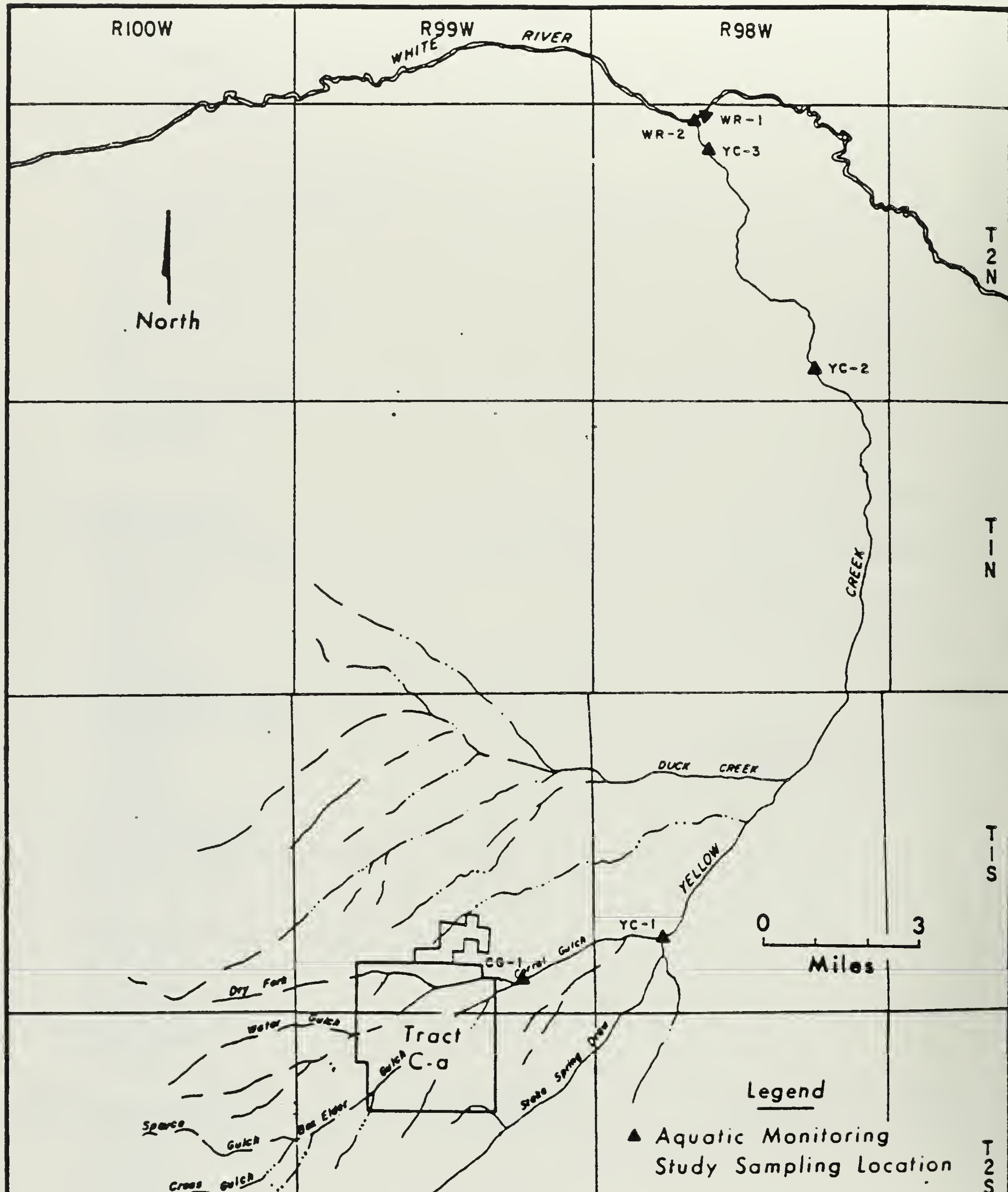

Figure 4-1. Sample Site Locations

4.1 ABIOTIC COMPONENTS

A. Physical Measurements

1. Objectives

The physical measurement program is designed to monitor selected physical parameters at MDP aquatic sampling stations and relate these data to water quality and aquatic biota conditions. The parameters selected for monitoring are those which may be indicative of effects related to project activities and which have been found to be particularly significant to the important aquatic organisms observed during baseline studies. Chemical parameters, such as dissolved oxygen, which were recorded in conjunction with the physical measurements are also presented and discussed in this section.

2. Methods

Methods used to collect physical stream data were described in MDP monitoring Report 1, (RBOSC 1978a) and are not repeated herein.

3. Results and Discussion

April 1981 data from each sampling station are presented in Table 4-2. A comparison of physical and chemical measurements collected in April 1981 with results obtained during April sampling of previous years is provided in Appendix 4-1.1.

The data in Appendix 4-1.1 indicate year-to-year variability in physical and chemical parameters. However, no trends or permanent changes are noted in any given parameter. This variability could have resulted from a number of factors including amount of runoff from melting of winter snowpack and recent precipitation, ground water reinjection tests, operational discharge and weather conditions just prior to and during sampling.

Table 4-2 Physical and Chemical Characteristics of Streams, RBOSC MDP Aquatic Studies (April 1981)

Parameter	Station					
	CG-1	YC-1	YC-2	YC-3	WR-1	WR-2
Water temperature (°C)	10	11	14	10	12	17
Conductivity (µmhos/cm)	1,390	1,950	2,975	3,400	400;375;400[2/]	550;550;400[2/]
Dissolved oxygen (mg/l)	6.9	10.8	10.3	10.4	8.8	8.9
Alkalinity, total (mg/l)	500	570	865	1,385	153	173
pH	7.7	8.1	8.0	8.3	7.7	7.7
Substrate[1/]	Gr	Sa,Si	Gr,Si	Si,Sa	Co,Si	Co,Si
Width	2-4'	6'	1-5'	2.5'	54'	58'
Depth	1-4"	1-5"	4"	2-7"	0.6-1.9'	0.7-1.8'
Velocity (ft/sec)	1.5	0.6	0.5	1.6	1.2-2.7	0.4-2.3

1/ Substrate abbreviations: Gr = gravel; Sa = sand; De = detritus; Co = cobble; Si = silt

2/ Measurements made at side, center, side, respectively

B. Water Quality Measurements

1. Objectives

Water quality in many cases, determines the potential uses of the waters of White River and affects the distribution and abundance of White River biota. Measurement of certain key chemical parameters at the sampling stations in the study area provide an index of the water quality. These parameters are the same as those measured for the hydrology monitoring program (see Section 5.1).

2. Methods

Methods used to collect and analyze water quality samples are described in Section 5, and are not repeated here.

3. Results and Discussion

Water quality data collected from all stations during April 1981 are presented in Table 4-3. A comparison of results obtained in April 1981 at the two White River stations WR-1 and WR-2 to the data obtained during previous years is provided in Appendix 4-1.2.

The data in Appendix 4-1.2 indicate little change in White River water quality from baseline conditions. No large difference between the water quality above and below Yellow Creek has occurred since the initiation of project activities. During April there was a large fluctuation in turbidity in the five year's samples. However, this fluctuation may have been related to the coincidence of sampling during spring runoff in 1975, 1979 and 1980. The 1978 and 1981 sampling occurred before the peak runoff period.

Table 4-3 Water Quality Data for the April 1981 MDP Studies (data expressed in mg/l unless otherwise noted)

Parameter	CG-1	YC-1	YC-2	YC-3	WR-1	WR-2
Ammonia (NH_3)	0.23	0.09	0.26	0.11	0.18	0.15
Arsenic (As)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron (B), sol	0.5	0.7	0.7	0.7	0.3	0.3
Bicarbonate (HCO_3)	582	686	1,027	1,522	123	120
Calcium (Ca), sol	80	140	63	36	50	50
Carbonate (CO_3)	<1	<1	1.21	7.12	<1	<1
Chloride (Cl), sol	17	131	32	118	17	15
Dissolved Organic Carbon (DOC)	3	8	8	12	6	<3
Fluoride (F), sol	0.23	0.18	0.31	0.76	0.11	0.09
Iron (Fe), sol	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium (Mg), sol	80	160	270	140	11	12
Mercury (Hg), sol	<0.3	0.6	<0.3	<0.3	<0.3	<0.3
Molybdenum (Mo), sol	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate (NO_3), sol	<0.01	<0.01	<0.01	0.16	<0.01	0.03
Phosphates, total (PO_4), sol	<0.01	<0.01	0.03	<0.01	<0.01	<0.01
Potassium, (K), sol	1.3	1.7	3.1	3.1	1.1	1.2

Table 4-3 (continued)

Parameter	CG-1	YC-1	YC-2	YC-3	WR-1	WR-2
Selenium (Se), sol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silica (SiO_2), sol	25	21	17	8	11	11
Sodium (Na), sol	160	220	430	820	20	26
Solids, dissolved	1,052	1,728	2,584	2,736	276	284
Sulfate (SO_4), sol	387	713	1,195	909	92	122
Turbidity (JTU)	1	2	1	7	44	47
Vanadium (V)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

sol = soluble
JTU = Jackson Turbidity Units

4.2 BIOTIC COMPONENTS

A. Periphyton

1. Objectives

Sensitivity of periphyton to changes in their environment has been well documented (Cholnoky 1968; Lowe 1974; Hutchinson 1975; Whitton 1975; Patrick 1977). Species composition and relative abundance of the total periphyton community and key periphyton species can provide good indicators of potential project effects on Tract C-a vicinity aquatic systems. Periphyton communities are amenable to sampling techniques which provide a good quantitative data base for identifying changes quickly and accurately. Therefore, the study of periphyton communities is an important part of the MDP Monitoring Program. Species composition, relative abundance and diversity are the periphyton parameters being measured.

2. Methods

Methods used for identification and enumeration of the periphyton were described in MDP Report 5 (RBOSC 1980a) and are not repeated herein. The program was modified somewhat in that the analysis of periphyton biomass was discontinued and the number of samples collected was changed. Under the revised Scope of Work, six replicate samples were collected from each station. Previously, four replicates from the White River and Corral Gulch Stations and 8 replicates from the Yellow Creek Stations were collected. This change was made to improve the statistical validity of the analysis.

3. Results and Discussion

In April 1981, a total of 123 taxa was identified from the periphyton samples. Periphyton identification and enumeration data are provided in Appendix 4-2.1. A list of taxa encountered at each sampling station is presented in Appendix 4-2.2. Density calculations are given in Appendix 4-2.3. A comparison of periphyton data collected at the six sampling stations are provided in Table 4.4. A summary and comparison of mean densities of the most abundant taxa (representing

Table 4-4 Comparison of the Mean Densities of the Most Abundant Species (>1% of Total Density) in the Periphyton at all Stations Sampled During RBOSC MDP April 1981 MDP Studies.

Taxa	Density (units/mm^2)					
	CG-1	YC-1	YC-2	YC-3	WR-1	WR-2
Division Bacillariophyta						
Achnanthes affinis		6,949		2,538		
A. lanceolata	110	622				
A. minutissima	74	184	318		327	6,858
Cocconeis placentula		152				
Cyclotella meneghiniana		1,169		90		
C. minuata		194			210	
C. minuata var. silesiaca				301		722
Diatoma tenue var. elongatum		430				
D. vulgare					200	
Epithemia sorex					866	771
Fragilaria capucina			132			
F. vaucheriae	201	1,251				
Gomphonema angustatum						171
G. olivaceum	22				214	
N. halophila			80			
N. notha					270	177
Navicula secreta var. apiculata	74	236				
N. viridula					2,927	2,050
N. dissipata						407
N. frustulum		271	341		189	395
N. holsatica	84		442			
N. linearis	21					
N. palea						200
Rhoisosphenia curvata					2,333	274
Rhopalodia gibba			543			
R. musculus			188			
Surirella ovata				212		
S. minuscula		236				
S. pulchella var. lanceolata				148		
Division Chlorophyta						
Bulbochaeta sp.			5,272	1,467		
Cladophora sp.					3,399	2,161
Enteromorpha sp.		2,472				

Table 4-4 (continued)

Taxa	Density (units/mm^2)					
	CG-1	YC-1	YC-2	YC-3	WR-1	WR-2
Division Cyanophyta						
Anabaena spp.			388			
Phormidium spp.						466
Division Rodophyta						
Batrachospermum sp.	904					
TOTAL DENSITY 1/	1,598	14,954	7,942	4,930	12,045	16,708

1/ Total density also includes density estimates of less abundant periphyton not listed in the tables.

greater than one percent of the total density) from April 1981 with the results from previous April (1975-1979) samples are presented in Appendix 4-2.4.

Total mean periphyton density volumes varied from 16,708 units/mm^2 at Station WR-2 in the White River to 1598 units/mm^2 at Station CG-1 in Corral Gulch in April 1981. The total mean periphyton density in Corral Gulch (Station CG-1) was higher than the values of April samples in 1978 and 1980 but lower than the values for 1975, 1976 and 1979. The April 1981 mean periphyton densities in Yellow Creek (Station YC-3) and the White River Stations (WR-1 and WR-2) were generally higher than in April of previous years.

At the Corral Gulch Station CG-1, the Chantransia-phase of Batrachospermum was the dominant alga in April 1981. This red alga is typically found in springs or springbrook habitats (Ward and Dufford 1979). Achnanthes lanceolata, A. minutissima, Fragilaria vaucheriae, Gomphomena olivaceum, Navicula secreta var. apiculata, Nitzschia holsatica and Surirella ovata were the dominant diatom species recorded for April 1981. These organisms were also dominant or present during April 1979 and 1980. Achnanthes minutissima has been reported as a dominant taxon at Station CG-1 throughout the RBOSC baseline and monitoring studies. The periphytic algae which were dominant in 1979, 1980 and 1981 are common in this region and characteristic of waters with high alkalinity, high dissolved oxygen and medium organic load where oxidation is proceeding (Lowe 1974). The periphyton which were dominant at Station CG-1 in years prior to 1979 are characteristic of a similar environment with a slightly lower organic load.

At the Yellow Creek Station YC-1, which is located just below the confluence of Corral Gulch and Stake Spring Draw, the dominant taxa in April 1981 were Enteromorpha sp., Achnanthes affinis, A. lanceolata, A. minutissima, Cyclotella meneghiniana and Fragilaria vaucheriae along with Cocconeis placentula, Cymbella minuata, Diatoma tenue var. elongatum, Navicula secreta var. apiculata, Nitzschia frustulum and Synedra minuscula. The green algae, Enteromorpha, generally develops best in saline conditions (Smith 1950; Hutchinson 1975). The dominant diatoms are characteristic of waters with high alkalinity and medium-low organic load (Lowe 1974).

At the Yellow Creek Station YC-2 the dominant periphytic algae in April 1981 were Bulbochaeta sp., Anabaena sp., Achnanthes minutissima, Fragilaria capucina

Nitzschia frustulum, Nitzschia holsatica, Rhopalodia gibba and R. musculus. The latter two diatoms are indicators of water with high conductivity (Patrick and Reimer 1975).

At Station YC-3 in the Yellow Creek the dominant taxa in April 1981 were Bulbochaeta sp., Achnanthes affinis, Fragilaria capucina, Surirella ovata and Synedra pulchella var. lanceolata. Surirella ovata is reported to have its best development during low water temperatures and usually has its maximum growth in the spring (Round 1973). Achnanthes affinis and Fragilaria capucina prefer alkaline waters (Patrick and Reimer 1966), and Synedra pulchella var. lanceolata is found in waters having high mineral content (Patrick and Reimer 1966).

At Stations WR-1 and WR-2 in the White River the April 1981 dominant taxa included Cladophora sp., Achnanthes minutissima, Cymbella minuta, Epithemia sorex, Navicula viridula, Nitzschia frustulum and Rhoicosphenia curvata. The diatoms at these stations in past years are similar in composition to the species observed in April 1981. The green alga Cladophora is usually associated with medium to high organic load and high light intensities (Whitton 1975). The increase in density of Cladophora in the White River in April 1981 was probably due to these conditions produced by low winter and spring flows in 1981 compared to previous years.

Fluctuations in spring flow in the study period as well as changes in water temperature may be factors causing the variations observed throughout the study period. High water tends to have a scouring effect in periphyton communities resulting in reduced densities. Conversely, low flow and warm water promote periphyton growth. High flow also tends to flush detritus from the system, whereas low flow does not. Therefore, algae which experience their maximum growth (e.g., Cladophora) in waters with medium-high organic load are favored during low flow years.

In summary, periphyton densities were generally higher at the sampling stations during April 1981 than in previous years. The periphyton of Corral Gulch are characteristic of waters having high alkalinity, high dissolved oxygen and medium organic load. The algae of Yellow Creek are generally found in waters with high conductivity. The flora at both White River stations are usually associated with alkaline waters having medium-high organic load.

B. Benthos

1. Objectives

Benthic macroinvertebrates constitute the major component of the secondary trophic level in aquatic ecosystems on and near Tract C-a. Their limited mobility and well-documented susceptibility to physical and chemical changes in their environment make them an important element of the MDP Monitoring Program (Kolkowitz and Marsson 1909; Hynes 1960; Tarzwell 1965; Cairns and Dickson 1973; Hart and Fuller 1974; Hilsenhoff 1977; Beck 1977; Hubbard and Peters 1978; Harris and Lawrence 1978; Surdick and Gaufin 1978). Data collected on benthos species composition, relative abundance and diversity at all sampling stations will permit the evaluation of development activity on benthos as well as identification of potential impacts on other components of the aquatic system.

2. Methods

Methods used for the benthos sampling program were described in MDP Report 5, (RBOSC 1980a) and are not repeated herein.

3. Results and Discussion

Macroinvertebrate data collected during the April 1981 MDP aquatic sampling program are presented in the following manner: Enumeration data and a list of taxa collected at each site are provided in Appendices 4-2.5 and 4-2.6. Macroinvertebrate densities for each site are presented in Appendix 4-2.7. A comparison of April 1981 macroinvertebrate densities at the six sampling stations are shown in Table 4.5. Comparison of these data to data from April of previous years is provided in Appendix 4-2.8 for all stations except YC-1 and YC-2 (new stations).

Of the four stations sampled during April 1981 that were sampled in previous years, taxonomic composition of the major benthic taxa did not change appreciably. At Station YC-3 (Yellow Creek) and WR-2 (White River) densities were similar to those observed in April 1980. At Station CG-1 (Corral Gulch) a reduction in

Table 4-5 Comparison of Major Benthic Macroinvertebrate Taxa Observed During April 1981 RBOSC Aquatic Monitoring Studies at all Sampling Stations

Taxa	Density (Mean Organism/m²)					
	CG-1	YC-1	YC-2	YC-3	WR-1	WR-2
Nematoda		19			7	
Oligochaeta	19	544	1,495	39	1,178	576
Hirundinea			369			
Crustacea			434			
Odonata				7	7	
Ephemeroptera	26	129			505	608
Plecoptera	13				136	84
Coleoptera	13	246	39		7	
Trichoptera		7		7	78	686
Lepidoptera						13
Diptera1/	39	1,036	278	142		78
Chironomidae	129	718	45	1,178	647	84
Mollusca			265			
TOTAL2/	252	2,699	2,945	1,385	2,563	2,129

1/ Diptera other than Chironomidae

2 Total density also includes density estimates of less abundant taxon not listed in the table.

the number of Chironomidae resulted in a greatly decreased density from 1980 results. At Station WR-1 (White River) total benthic macroinvertebrate density was increased due to a large increase in the number of Oligochaeta found in samples.

Macroinvertebrate density at Station CG-1 during April 1981 was lower than that observed in 1980 but was similar to the densities observed during 1978 and 1979. Densities prior to 1978 were higher than more recent samples. In all years except 1978 and 1979 Chironomidae have been the dominant taxon accounting for as much as 96% of the total densities. As a result, the low Chironomidae density in 1981 (130 organisms/m^2 vs 1372 organisms/m^2 in 1980) resulted in a low total density. The lack of dominance by any one taxon and the high number of taxa represented resulted in a high species diversity index at this station in April 1981. Most noticable about 1981 benthic samples from Station CG-1 was the presence of two groups, Ephemeroptera and Plecoptera, that had not been observed at the Station since 1977. Station CG-1 presents a relatively harsh environment for aquatic organisms. The substrate is unstable and the erosional nature of the stream at this station probably prevents most macroinvertebrate groups from becoming established. Under these conditions, organisms such as Chironomidae and Oligochaeta, which typically have short life cycles as well as the ability to complete several generations between perturbations, are best adapted to survive. The presence of Ephemeroptera and Plecoptera in 1981 samples may indicate somewhat more stable conditions at this location than in previous years.

As in previous years, Chironomidae dominated the benthic fauna at Station YC-3 in lower Yellow Creek. Total density was within 4% of the density recorded in April 1980; 1979 density figures, however, were much lower primarily as a result of few Chironomidae in samples taken. This apparent shift in the abundance of Chironomidae in 1980 and 1981 may have been due to the physical factors which control the events in the life history of these organisms. It is likely that normal year-to-year variations in the physical factors such as temperature degree days, flow patterns, etc. which influence the time of hatching and emergence are sufficient to have delayed the Chironomidae life cycles in 1979 compared to 1980 and 1981 (Hynes 1970; Clifford 1978; Lehmkuhl 1979; Malley and Reynolds 1979; Rosenberg 1979).

In April 1981 the White River Stations, WR-1 above and WR-2 below the confluence of Yellow Creek, had abundant and diverse macroinvertebrate populations typical of larger Colorado streams. Total density at Station WR-1 was greater than any year previously sampled; the large number of Oligochaeta, Ephemeroptera and Chironomidae taxa in 1981 samples was largely responsible. Total density at Station WR-2 was larger than the two previous April samples (1979 and 1980). The taxonomic composition of samples from both was similar to that found during April 1979 when Oligochaeta and Emphemeroptera taxa dominated the samples.

Two new stations were sampled in Yellow Creek during April 1981: YC-1 above where Yellow Creek disappears into the alluvium and YC-2 below where flow reappears. Total macroinvertebrate density was similar at both stations although the taxonomic composition of the samples differed. Station YC-1 was dominated by Diptera, primarily Chironomidae larvae, which accounted for about 65% of the total density. Other prominent taxa were Coleoptera (i.e. Agabus sp.) and Oligochaeta. At Station YC-2 Oligochaeta was the dominant taxon accounting for about 51% of the total density. Crustacea (i.e., Gammarus lacustris), Chrionomidae and Mollusca were also well represented in samples.

In summary, benthic macroinvertebrate densities during April 1981 were typical of the variation seen in densities at stations sampled during previous April sampling periods. Total density was lower than April 1980 results at Station CG-1 due to a paucity of Chironomidae in the samples, but was increased over April 1980 at the White River Stations (SR-1 and WR-2). Little change was observed in the total density at YC-3 (Yellow Creek). The two new stations in Yellow Creek (YC-1 and YC-2) showed similar densities; total density was higher, however, than the other Yellow Creek Station (YC-3). Chironomidae and Oligochaeta were the dominant taxa observed over all samples from all stations.

4.3 SUMMARY AND CONCLUSIONS

The data for the physical parameters measured at each aquatic sampling station varied appreciably from year to year. Measurements for April 1981 fell within the range of the previous years, and no large fluctuations were demonstrated by a comparison of the physical and chemical data obtained in April 1980 and April 1981.

The data for the water quality parameters measured in the White River (Stations WR-1 and WR-2) changed very little from baseline conditions. No major differences were found between the water quality data obtained on the White River above and below the confluence with Yellow Creek.

In April 1981 a total of 123 taxa were identified from the periphyton samples. Total mean periphyton densities varied from 16,708 units/mm^2 at Station WR-2 on the White River to 1598 units/mm^2 at Station CG-1 in Corral Gulch. Total mean periphyton densities in Corral Gulch (Station CG-1) were higher than the values of April samples in 1978 and 1980 but lower than the values for 1975, 1976 and 1979. Total mean periphyton densities in Yellow Creek (Station YC-3) and the White River (Stations WR-1 and WR-2) during April 1981 were generally higher than in April of previous years.

Taxonomic composition of the major benthic taxa did not change appreciably during April 1981 at stations sampled previously; total densities were also within the range observed during previous Aprils. A reduction in the number of Chironomids lowered the total density during April 1981 at Station CG-1 as compared to April 1980. Densities at the other three stations sampled previously (YC-3, WR-1 and WR-2) were similar to or greater than April 1980 densities. The dominant taxa over all stations were Chironimidae and Oligochaeta.

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SECTION 5

HYDROLOGY STUDIES

This report presents the data and analysis of the hydrologic monitoring program for Tract C-a for the period December 1980 through May 1981. The material presented in this report is divided into three general categories: surface water, groundwater, and development activities monitoring.

The surface water and groundwater monitoring programs have been conducted since the baseline period (1974-1976). This monitoring program was initially designed to define the hydrological characterstics of the region on and near Tract C- a and more recently to assist identification of impacts of the oil shale development activities on Tract C-a. Surface water has been collected from springs and seeps and at surface water gaging stations. Groundwater data have been collected from alluvial monitor holes and from upper aquifer and lower aquifer wells.

The development activities monitoring program is designed to document the quantity and quality of waters which are displaced as a result of the oil shale development activities. These activities include upper aquifer dewatering and reinjection, discharge of upper aquifer water into surface streams, land disturbance and other activities that may affect the hydrology of Tract C-a. Monitoring stations for the development activities program have been installed as needed in the proximity of development facilities. This monitoring program was formerly designated the "operational" monitoring program.

Data were collected at surface gaging stations by the United States Geological Survey (USGS). Other data were collected as described herein by RBOSC and its subcontractors. Hydrologic data gathered during this reporting period are presented in Volume 2--Appendices. USGS and erosion/sedimentation data collected prior to December 1980 but not previously reported are also included in the appendices.

5.1 SURFACE WATER

A. Streams

1. Objectives

The objective of the stream monitoring program is to measure and evaluate changes in water quantity and water quality relative to the baseline period.

2. Methods

Surface water quality and quantity are monitored through the use of six surface water gaging stations by the U.S. Geological Survey (USGS). The gaging station locations are illustrated on Map 1 of MDP Monitoring Report 4 (1979b). Conductivity, pH, temperature, and flow are monitored on a continuous basis. Quarterly monitoring includes the major inorganic ions, pH, and alkalinity. Semiannual analyses are performed for an extensive list of trace constituents for all six surface water gaging stations. In addition to the monitoring done by the USGS, water temperature, conductivity and pH are monitored at Station D on a daily basis by tract personnel because this station is located downstream from tract activities.

3. Results and Discussion

a. Physical parameters - Station A, Dry Fork was dry throughout most of the 1980 water year. Flow was observed for 5 days (not continuous) during April-May 1980 and two separate days in August 1980. The maximum flow was 0.37 cfs. Station A was dry throughout October 1980 - March 1981. (Appendix 5-1.1).

Station C (Box Elder Gulch near the west Tract boundary) experienced flow during October 1980 (one day, 0.01 cfs), and several days in February and March 1981. The maximum daily mean flow observed was 0.06 cfs in March.

Flow was observed at Station E (Box Elder Tributary) during February and March 1981 but was dry from October 1980 - January 1981. The peak daily mean discharge was 0.38 cfs in February.

Average daily discharge (cfs) for the mid-year report period for the two Corral Gulch Stations (B and D) and the Yellow Creek Gage (Station F) are shown below:

1981 WATER YEAR

Station	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
B	.33	.23	.23	.15	0	<.01
D	.90	.66	1.22	.79	.77	.79
F	2.57	2.55	2.55	2.48	2.22	2.48

These flows are generally comparable to flows observed during baseline characterization studies on Tract C-a. They reflect the more normal flow regime experienced over the past year as surface discharges from site dewatering operations have been minimized.

b. Chemical Parameters - Water quality data are reported by the USGS for this report period and are presented in Appendix 5-1.1

B. Springs and Seeps

1. Objectives

The objective of monitoring and observing major springs and seeps is to measure and evaluate changes in the physical parameters (flow, conductivity, temperature, and pH) relative to the baseline period.

2. Methods

Seven springs and seeps are included in the monitoring program. Sampling locations are described in MDP Monitoring Report 4(1979b). Specific conductance is measured by the use of a conductivity meter. Spring discharge is measured by using a weir, a flume, or by integrating cross-sectional velocities. Flows are measured to evaluate possible impacts of tract dewatering or other development activities on the springs.

Variations in the water quality of the springs and seeps are evaluated using conductivity data. The rationale for using conductivity as a detector parameter is based on high correlation with changes in major inorganic ions during the baseline monitoring program.

Near the end of this report period, two spring stations were added to this program as a result of reanalysis of monitoring needs:

- Spring 20 (SPG-20) - near the headwaters region of Duck Creek

- Miller's Spring (SPG-MILL) - flow separate from Corral Gulch near USGS station D.

Data for these and other spring stations are presented in Appendix 5-2.2.

3. Results and Discussion

The results of spring/seep sampling during the report period are presented in Table 5-1 along with data from previous years of the monitoring program. The 1981 observations are generally comparable to earlier data. Conductivities at Spring 14 (east of Tract C-a) appear somewhat lower than previous measurements although no real trend is apparent.

C. Erosion Stations

1. Objectives

The objective of the erosion station monitoring program is to measure changes in stream morphology during the Modular Development Phase, and to evaluate the cause of such changes.

2. Methods

At each erosion station, a stake is located on either side of the channel and measurements of elevation are taken every six inches on a straight line between the two stakes measuring from the left bank looking downstream. The locations of these erosion monitoring stations are shown in MDP Monitoring Report 4 (1979b).

Table 5-1. Summary of Field Data Collected at Springs and Seeps, Tract C-a

			Report Year					
Station	Parameter[1/]	Statistic	Baseline 1975-76	1977	1978	1979	1980	1981[4/]
SPG-01	Flow	Maximum	..	21.0	48.0	20.0	150	..
		Minimum	..	..	5.0	1.0	..	..
	Temperature	Maximum	19	6.0	8.0	8.3	7.8	8.0
		Minimum	1	..	7.5	7.5	7.7	7.7
	Specific Conductance	Maximum	950	920	910	850	920	850
		Minimum	825	..	870	800	750	800
	pH	Maximum	..	..	7.4	7.5	7.6	7.2
		Minimum	..	..	7.1	7.1	7.1	6.8
SPG-02	Flow	Maximum	..	13.0	68	255	495	..
		Minimum	..	..	6	0.1	..	..
	Temperature	Maximum	11	..	9.0	9.0	9.0	9.4
		Minimum	7	..	8.0	8.5	8.0	7.7
	Specific Conductance	Maximum	1200	1000	990	1120	1010	1050
		Minimum	1000	..	990	800	910	925
	pH	Maximum	..	..	7.2	7.7	7.6	8.8
		Minimum	..	..	7.2	7.0	7.5	7.4
SPG-03	Flow	Maximum	..	21	9	49	32	..
		Minimum	..	..	9	0.7	42	..
	Temperature	Maximum	2.0	1.0	7	13.8	11.0	9.7
		Minimum	5.0	..	5	7.5	2.0	8.0
	Specific Conductance	Maximum	1300	1025	1280	1300	1460	990
		Minimum	850	..	1250	950	1000	975
	pH	Maximum	..	..	7.6	9.2	8.2	8.0
		Minimum	..	..	7.1	7.0	8.0	7.8

Table 5-1. (Continued)

Station	Parameter[1/]	Statistic	Baseline 1975-76	1977	1978	1979	1980	1981[4/]
SPG-04	Flow	Maximum	..	..	..	94	230	..
		Minimum	..	..	..	..	260	..
	Temperature	Maximum	..	..	..	10.5	15.0	8.9
		Minimum	..	..	..	..	3.0	0.5
	Specific Conductance	Maximum	..	..	..	1000	1300	1175
		Minimum	..	..	..	..	1000	900
	pH	Maximum	..	..	..	9.0	8.2	8.2
		Minimum	..	..	..	..	7.8	7.7
SPG-05	Flow	Maximum	..	..	..	75	1410	..
		Minimum	..	..	..	..	..	..
	Temperature	Maximum	22	..	..	11	13.8	20.0
		Minimum	3	..	..	6	1.2	5.5
	Specific Conductance	Maximum	1500	..	..	1600	1400	1325
		Minimum	1300	..	..	1280	..	1200
	pH	Maximum	..	..	..	8.0	8.2	8.2
		Minimum	..	..	..	7.0	7.7	8.0
SPG-08	Flow	Maximum	..	21	112	130	350	..
		Minimum	..	..	9	..	35	..
	Temperature	Maximum	12	10.5	12	7.7	9.9	8.0
		Minimum	5	..	4	..	5.5	7.3
	Specific Conductance	Maximum	1100	1140	1200	850	1140	950
		Minimum	850	..	1000	..	900	950
	pH	Maximum	..	..	7.0	7.7	7.9	8.9
		Minimum	..	..	6.8	..	7.4	7.3

Table 5-1. (Continued)

Station	Parameter[1/]	Statistic	Baseline 1975-76	1977	1978	1979	1980	1981[4/]
SPG-14[4/]	Flow	Maximum	..	19	69	2	3	..
		Minimum	..	..	14	..	3	..
	Temperature	Maximum	19	3.5	12	12	22	18
		Minimum	..	..	2.5	6.6	1.0	7.0
	Specific Conductance	Maximum	2000	1750	1700	2700	3760	1850
		Minimum	1550	..	875	2000	2250	1325
	pH	Maximum	..	..	7.8	8.0	8.2	8.1
		Minimum	..	..	7.0	7.7	7.8	7.8
SPG-20[3/]	Temperature	Maximum	..	..	..	..	10.0	9.8
		Minimum	..	..	..	..	..	7.8
	Specific Conductance	Maximum	..	..	..	..	1100	1175
		Minimum	..	..	..	..	..	950
	pH	Maximum	..	..	..	..	7.9	7.7
		Minimum	..	..	..	..	..	7.5

1/ Units: flow - gal/min; temperature - °C; specific conductance - µmhos/cm at 25°C; pH - pH units

2/ Spring 14 was disturbed by road construction in 1979

3/ Single observatin, 10/24/80

4/ Current report year, two samples - January and April 1981

3. Results and Discussion

Channel cross-sections for each of the erosion-sedimentation stations are shown in Appendix 5-1.2.

Station 1A is located upstream of MDP discharge points. Some downcutting of the channel is indicated in June, 1980, probably due to spring snowmelt runoff.

Station 3 is located below the MDP flume discharge point. This station exhibits minor channel shifting and associated sedimentation.

Station 4 appears very stable with only minor channel shifts.

Stations 5 and 6 are relatively stable and display very little channel drift or cut.

Station 7 exhibits minor fill and cut due to spring runoff.

Station 8 east of the Tract exhibited little to no channel cutting or shifting.

Station 9 exhibited minor channel fill and shift.

Station 10 remained stable and Station 11 deepened in March 1980 by one foot relative to previous observations.

5.2 GROUNDWATER

A. Alluvial Aquifers

1. Objectives

Water levels and water quality of alluvial aquifers are being monitored, during the Modular Development Phase, to detect changes in the characteristics of the alluvial aquifers, evaluate the significance of those changes observed and to assess the causes of the changes.

2. Methods

The alluvial monitoring program is described in the MDP Scope of Work (January 1979). Some sampling changes were implemented at the end of this report period. These changes are described in the updated Scope of Work approved in May 1981. Sampling methods have not been altered.

3. Results and Discussion

a. Physical parameters - Eight of the alluvial monitoring holes were found to be dry during the 1980-1981 reporting period. For the remaining alluvial holes, the physical data obtained during this reporting period are listed from upstream to downstream on Box Elder Gulch, Corral Gulch and Yellow Creek, respectively. Hydrographs and graphs for all the alluvial holes are shown in Appendix 5-2.1.

GS-S8 is located in Box Elder Gulch at the west boundary of the tract and reflects the conditions of alluvial water entering the tract. Data for 1981 are within the general range observed during the baseline. During MDP, average water levels and temperatures had increased slightly but a slight decline is observed for 1980-1981. Conductivity and pH reflect baseline values.

GS-S7 is located in Corral Gulch at the west boundary of the tract and reflects conditions of alluvial water entering the tract. The physical data for GS-S7 are shown in Appendix 5-2.1. The temperature increased in March and April. Conductivity and pH remained fairly stable. The water level increased beginning in March and continued through April. An increase in water temperature accompanied the rise in water level.

GS-S27 is located in Corral gulch at the east tract boundary and reflects conditions in alluvial water leaving the tract. The physical data are plotted in Appendix 5-2.1. The hydrograph shows a very steady water level throughout the reporting period. A minor rise is indicated in the middle of May. This is a result of a calibration change in measurement of approximately three feet. A three foot section of surface-extension pipe was removed in order to obtain dual completion measurements. It was discovered that previous measurements (continued when the recorder was removed) were being made on the shallow completion rather than the deep completion. Therefore, the previously reported GS-S27D measurements have been relabeled GS-S27S and new GS-S27D measurements have been initiated. The temperature of GS-S27S fluctuated between 8°C and 11°C and the conductivity and pH remained stable and were comparable to baseline conditions.

GS-S11 and GS-S11A are located in the Corral Gulch alluvium two miles downstream from the east tract boundary. Both wells are dual completions with shallow and deep zones being monitored. GS-S11S (shallow) was dry from December through May. GS-S11A was dry during the reporting period. GS-S11D (deep) contained water in December and early January but has been dry thereafter. Insufficient water was in the well to allow collection of samples for physical parameters.

GS-S24 is located in the Corral Gulch alluvium about three miles downstream from the east tract boundary. The physical data plots are presented in Appendix 5-2.1. The water level did not respond to any influence as is displayed by the steady hydrograph. Water levels are comparable to 1980 data. The conductivity, temperature and pH fluctuated somewhat.

Shallow and deep holes at GS-S28 and GS-S28A, GS-S29 and GS-S29A are located in Yellow Creek alluvium approximately six and one-half miles downstream from the eastern tract boundary. Two new wells GS-S30 and GS-S30A are also located in Yellow Creek approximately 13.5 miles downstream from the eastern tract boundary. Monitoring of these wells began during the 1980 report period. The physical data are plotted in Appendix 5-2.1. The water levels for the shallow and deep wells associated with GS-S28 series remained stable during this reporting period. Seasonal fluctuations of pH, conductivity, and temperature are apparent in both shallow and deep series completions. The physical parameters for GS-S28D fluctuated less than the shallow series wells. In addition, the conductivity is lower at GS-S28D with an average of 1900 μmhos/cm compared to 2550 μmhos/cm for GS-S28AD.

The water levels of the shallow and deep wells GS-S29, GS-S29A, and GS-S30 remained stable during this reporting period. The temperature fluctuated, pH was stable, and conductivity increased slightly in GS-S29D but remained stable in all other wells.

b. Chemical parameters - Water quality analyses of alluvial wells are located in Appendix 5-2.2.

Data collected during the report period generally indicated that alluvial water quality was comparable to that observed during the 1980 report year. Report period data (Appendix 5-2.2) were compared to 1980 data for wells GS-S29D, GS-S27, GS-S7 and GS-S8. Data for 1980 for wells GS-S30D and GS-S24 was not collected and thus no comparison could be made.

Although the recently observed water quality was comparable to 1980 observations, some variation was noted. At GS-S29D sodium, bicarbonate, sulfate, fluoride and boron levels were somewhat lower than 1980 data, while calcium and DOC concentrations were greater. At GS-S8, sodium, bicarbonate, and TDS concentrations were greater than earlier data, and fluoride was lower. Calcium and sulfate levels at GS-S27 were also increased slightly over 1980 observations. Most of these observed variations were small and do not represent appreciable changes in water quality in the alluvial system.

B. Deep Oil Shale Aquifers (Upper and Lower)

1. Objectives

Deep (upper and lower) oil shale aquifers are being monitored during the Modular Development Phase for water level and water quality. These data are analyzed and compared with data collected during the baseline period for the purpose of detecting changes in the aquifer due to oil shale development activities.

2. Methods

Twenty-five upper aquifer and six lower aquifer wells have been included in the MDP monitoring program. The sampling program is described in MDP Monitoring Report 4 and in the January 1979 MDP Monitoring Scope of Work. Collectiion of field data (water levels, temperature, conductivity and pH) and samples for chemical analysis are included in this program. Recent changes in the monitoring program are presented in the revised MDP Scope of Work, approved in May 1981. These changes will be addressed in the year-end report.

3. Results and Discussion

a. Physical parameters - The deep aquifer physical data for this reporting period are presented in Appendix 5-2.1. In general, water levels in the upper aquifer near the mine responded to dewatering and reinjection. Natural recharge affected those along the north and west portions of the tract. Wells in the southeast corner of the tract showed some response to reinjection. Observed water temperatures, conductivity, and pH were generally comparable to measurements of the previous report period.

1. Upper aquifer wells - The hydrographs for wells AM-2AU and AM-3U showed that water levels were stable throughout the reporting period. (December 1980 - May 1981; Appendix 5-2.1). The hydrograph for CE-701U indicates stabilization after a rise of approximately 50 feet caused by

initiation of injection to TO-2U in June, 1980. The hydrograph for CE-702U indicates that the water levels are stable during periods of steady injection rates.

The hydrograph for CE-705AU shows the influence of dewatering activities. A small rise in water level during December was a result of dewatering well shutdowns during that month. This well appears to have stabilized in relation to drawdown associated with dewatering well GS-D8U. The conductivity, temperature, and pH show little variation.

The water levels in CE-707U remained nearly constant during this report period. CE-707U is located on a ridge between Dry Fork and Corral Gulch, upstream from the mine. Fluctuations in the past have been attributed to recharge of the upper aquifer from snowmelt infiltration.

The hydrograph of CE-708U showed a consistent water level from December through May. This monitoring station is located west of the graben, and water level fluctuations in the past have been attributed to normal recharge of the upper aquifer.

Well CE-709U is located relatively close to the mining activities on tract. The hydrograph for this hole shows a very gradual decline in water level with minor fluctuations which is a response to the dewatering activities.

GS-1U is located near the western border of the tract, some distance from the dewatering operation. The water level shows a gentle decline from December through May.

The steady rise in water level in GS-2-3U has stabilized from dramatic rises observed in 1980 after the initiation of TO-2U injection. This monitoring hole is within the cone of depression caused by the dewatering operation.

The GS-9U hydrograph shows a steady decline in water level through May with a brief rise in April.

GS-10U responded only to dewatering during the early portion of the project; however, since reinjection was reinitiated in September 1979, GS-10U water levels have risen. The short-term decline in December is attributed to the temporary shutdown of injection well GS-20U, located approximately 2000 feet away.

GS-12U is located in the graben in the southeast corner of the tract. Water levels in both GS-12U and GS-13U show little variation.

The hydrograph for GS-15U shows a very gradual rise after the initiation of reinjection to GS-20U and GS-21U.

The water level in GS-M1U has stabilized with continued response to reinjection at TO-2U. Minor fluctuations occurred during the stabilization period.

Well GS-M2U is far enough from mining activities and the recharge area that the water levels are steady. GS-M3U is also distant from tract activities and the hydrograph for this hole indicates a constant water level. The water levels of GS-M4U indicate continued drawdown on the order of two feet between December 1980 and May 1981. Monitoring well GS-M5U is located several miles northeast of the tract and is completed in the perched aquifer above the upper aquifer. The hydrograph indicates a stable water level.

Off-tract deep aquifer monitor holes GS-M6U through GS-M12U were drilled in mid-1980, M-GS-M7U, GS-M8U, and GS-M9U water levels have remained stable. GS-M6U reacted to dewatering and indicates a drawdown of about four feet between December and May. GS-M10 and GS-M12U hydrographs indicate response to reinjection occurring in the area of the southeast corner of the tract and parallel to the graben transecting Stake Springs Draw. GS-M11U, located in Stake Springs Draw, adjacent to GS-M10U, but inside the trace of the graben does not appear to respond to the reinjection and even indicates a small drawdown in water level. This water level decline may be due to lack of natural snowmelt recharge upgradient during the past year.

2. Lower aquifer wells - The water levels in the lower aquifer have not responded appreciably to dewatering; however, in past observations, a few of them appear to have responded to reinjection in the northeast corner of the tract. Fluctuations of physical parameters have been attributed to the presence of upper aquifer water near the boreholes that entered the lower aquifer before bridges were placed between the aquifers.

The water level in CE-702L has been stable during this report period. Gradual rises have been observed in past reports. Similarly observed water levels in CE-709L were relatively stable (Appendix 5-2.1). The hydrographs for GS-D17L, GS-4-5L, GS-15L, and TO-1L show stable water levels throughout the reporting period.

b. Chemical parameters - Water quality data for upper and lower aquifer wells are reported in Appendix 5-2.2.

3. Results and Discussion

a. Upper aquifer water quality - During the reporting period, upper aquifer water quality was very similar to that observed during the proceding year. Several wells exhibited slightly elevated (relative to 1980) levels of conductivity, TDS, and several major inorganic ions (sodium, calcium, magnesium, sulfate). Such wells included AM-3U, CE-701U, CE-702U, GS-M3U, GS-M6U, and GS-M8U. Decreased levels of fluoride and/or alkalinity (including bicarbonate and carbonate ions) were noted at wells AM-3U, CE-701U, CE-702U, CE-705AU, CE-707U, GS-10U, GS-M12U, GS-M2U, GS-M3U, GS-M6U, and GS-M8U. Several of these also exhibited slightly decreased levels of some of the major inorganic ions.

There also appears to be less scatter in the water quality data of many wells compared to 1980 observations. This may be attributable to equilibration within the upper aquifer system with the nearly steady state dewatering-reinjection program.

b. Lower Aquifer Water Quality - Lower aquifer water quality observed during the reporting period (Appendix 5-2.2) was similar to that observed during 1980. Somewhat lower levels of conductivity, DOC, TDS, sodium, bicarbonate, and boron were observed in CE-709L and GS-17L but these variations are probably not significant. Somewhat increased concentrations of fluoride, relative to 1980 data, were observed at CE-709L and GS-18L but no trends are apparent.

5.3 DEVELOPMENT ACTIVITIES MONITORING

1. Objectives

The objective of the development activities program is to directly monitor the facilities and activities associated with the oil shale development on Tract C-a. The monitoring stations associated with this program have been installed as needed, when a particular activity, such as dewatering, commenced. The development activities monitoring stations are located on-tract or in close proximity to development activities.

2. Methods

A location of these monitoring stations is shown on Map 1 of MDP Monitoring Report 4 (1979b). Many of the development activities which are being monitored as part of this program are associated with the dewatering of the upper oil shale aquifer. The functional dewatering wells were monitored for physical and chemical characteristics as are the holding ponds for the dewatering water. Four piezometers have been installed to detect any seepage from the East and West Retention Ponds.

There are six reinjection wells: GS-4-5U, GS-6U, TO-2U, TO-3U, GS-20U and GS-21U. Physical and chemical parameters were analyzed on samples collected from these wells during the reporting period. In addition, two springs were monitored to detect any possible impacts on surface water from the reinjection. One of these springs is located immediately upstream from Box Elder flume, and the other, Miller Spring, is located between Station D and the road. Discharges are measured from these springs, and physical parameters are determined from samples taken from them.

Water that is not reinjected or used consumptively is discharged. Discharge of the sewage effluent began in May at the MIS discharge flume. Daily and weekly sampling and analysis of permit-related parameters began when discharge was initiated. Five surface stations and three alluvial wells located in Corral Gulch and Yellow Creek are used to monitor the effects of this discharge. Water levels or flows were measured at these points and physical parameters were determined from samples collected at each point.

3. Results and Discussion

Data on flows, water levels, pH, conductivity, temperature and pH for development activities are presented in Appendix 5-3.1. Water quality data for the report period are listed in Appendix 5-2.2.

a. Dewatering - Mine dewatering was accomplished through the use of mine sumps and two dewatering wells (GS-D6U and GS-D8U). The total water production has generally ranged from 1700 to 2000 gpm. These flows are monitored as they are discharged to the West Retention Pond. Consumptive water needs have fluctuated from 100 gpm to 600 gpm averaging about 250 gpm. Total water disposal follows the pattern of water production fairly well, but fluctuates much more. At times, it appears there may be some recycling of water (100 to 200 gpm) consumed for plant operations.

b. Ponds - Two holding ponds on Tract C-a are utilized for temporary and permanent storage of various effluents associated with the development activities. Mine seepage water was pumped into the West Retention Pond. Surface runoff from the mine area was also collected in the West Retention Pond where the water is stored until needed for reinjection or consumptive use (fire water storage, retort operations, and potable water). The East Retention Pond is a holding pond used for sewage blowdown and other operations waste streams. The treated sewage effluent is now being discharged with the approval by the Colorado Department of Health and the OSO.

The conductivity of the West Retention Pond (Station YWRPOND) was stable at 1400 micromhos/cm. Temperature fluctuations are attributed to seasonal air temperature variations; pH remained relatively constant at about 8.0 although towards the end of May, a slight increase occurred.

Physical data for the East Retention Pond (Station YERPOND) indicated sudden changes that are attributed to pond turnover. Conductivity decreased radically in late January and then increased slightly in late April. Temperature and pH both changed at the same time, but inversely to conductivity.

Four piezometers are located downstream from the East and West Retention Ponds for the purpose of monitoring pond seepage. Water level observations were taken in each of the piezometers during the reporting period. Piezometer No. 3 was dry throughout the period. Piezometers No. 1, No. 2 and No. 4 (Stations YPZ-1, -2 and -4) sporadically contained water which was attributed to spring snowmelt and rainfall (Appendix 5-2.1).

Sour water/scrubber blowdown ponds 1-7 (Stations YSWPOND-1 thru -7) are monitored for water levels, field water quality, and detailed chemical compostion (Appendices 5-2.1 and 5-3.1). The pH and conductivity for ponds 1, 2, 3 and 6 reflect the high pH and conductivity expected in scrubber blowdown water. The following water level charges are due to leak detection and repair activities: Pond No. 1 in April - 3 feet of water pumped to pond No. 6; water from pond No. 2 was pumped to pond No. 5 until leaks were detected at the half full mark in late April; Pond No. 5 was then pumped back to No. 2 until No. 2 started leaking (early May) whereby No. 2 was pumped back to No. 5 following leak repairs.

Sour water ponds 4 and 7 water levels were variable during the report period due to the use of this water for recycling to Retort 0 during leaching studies. The pH in both ponds dropped in late April when leaching studies were completed and the sour water was pumped back into the ponds. Conductivities increased in Pond 7 and remained stable in Pond 4. The recycled sour water for the Retort 0 leachate study was pumped to Pond 7, as indicated on the water level hydrograph. Temperatures fluctuated seasonally and to some extent with inflow and outflow.

c. Composite reinjection - Water was reinjected from the West Retention Pond into the upper aquifer through wells GS-4-5U, GS-6U, TO-2U, TO-3U, GS-20U, and GS-21U. Almost all of the water produced through May (an average of about 1500 gpm) was reinjected. Conductivity and pH of the composite reïnjection were almost identical to West Pond measurements. Temperatures were also very similar to West Pond measurements.

Miller Spring is monitored to measure the effects of reinjection. Miller Spring has a very low flow but steady flow rate. The temperature, pH, and total suspended solids fluctuated but are relatively stable. Conductivity is somewhat higher than Box Elder Springs which is located approximately 1000 feet south of Miller Springs.

The water level at the windmill in Stake Springs Draw to the southwest of the tract is monitored. The hydrograph indicates a decreasing water level from December through May. The well is located to the southwest of the major graben crossing the tract and may not respond to dewatering or reinjection activities. The decline in water level may be the result of low recharge amounts this year. Other wells on tract that have typically responded to recharge, such as GS-9U, CE-707U, and CE-708U have responded little to not at all to recharge this year.

Flow at Box Elder Flume is also monitored to measure the effects of reinjection. Physical data is monitored daily at Station Met-3. The hydrograph shows a slightly increasing base flow from the springs' discharge in December. There was very little response to spring runoff in this report period. Conductivities at Station Met-3 remain fairly stable around 1500 micromhos/cm until spring runoff when they decreased to 1375 micromhos/cm. Temperature profile for Station Met-3 exhibits a normal seasonal fluctuation with numerous short-term fluctuations superimposed on it, probably caused by variation in the time of day the samples are taken. The pH varied between 8.0 and 7.5 during the report period.

d. Discharge monitoring - Minor discharge occurred in January and February. In May and early June sustained discharges of about 600 gpm were required. Physical data for the surface discharge in May is the same of dewatering well GS-D6U and GS-D8U. A series of monitoring stations are located in Corral Gulch to monitor the effects of excess dewatering discharge on stream flow. Overflow from the West Retention Pond is measured at the flume where it enters Corral Gulch. Regular discharge is piped to the culvert near the Visitors Center at the east tract boundary where there is another monitoring station. Further downstream, Station Met-3 is located at USGS Station D which is at the confluence of Box Elder and Corral Gulch. Box

Elder Flume is just upstream from Station D. The SEO flume, maintained by the State Engineer's Office, located just upstream from 24-Road Crossing, is also monitored.

Temporary discharges were made through the west retention pond flume in January and March to necessitate operational maintenance. Discharge of the sewage effluent began in May as reflected on the hydrograph. Total suspended solids fluctuated between a minimum of 4 and a maximum of 80, which was due to algae accumulation on the flume. Conductivity fluctuated between 1750 and 1950 micromhos/cm and pH fluctuated between 7.6 and 8.5. Temperature fluctuated between 10° and 15°C.

The hydrograph at the SEO Flume shows increased flow in May, however this has been determined to be measurement errors due to submergence of the flume. Conductivity decreased in February and March, but increased in March and April to pre-February measurements. The temperature appears to exhibit numerous short-term fluctuations around a seasonal trend with highest temperatures in April and May and also reflects the time of day the measurement is taken. The pH varied between 7.4 and 7.9.

Conductivities were stable at 1900 micromhos/cm until February and March when they decreased to 1800 micromhos/cm. The temperature exhibited a seasonal trend and the pH varied between 8.0 and 7.5.

e. Water quality monitoring - The water quality of the dewatering-reinjection system during the December 1980 - May 1981 period (Appendix 5-2.2) was comparable to that observed throughout 1980. Somewhat lower DOC concentrations were observed both in the West Retention Pond and in the composite reinjection flow (YCOINJ). In addition the pH and fluoride levels in the West Retention Pond were somewhat lower than was observed in 1980 but the changes were not great.

The East Retention Pond exhibited increase concentrations (relative to 1980) of conductivity, alkalinity, TDS, and major inorganic ions (magnesium, sodium, bicarbonate, and sulfate) but generally comparable levels of pH and fluoride were observed. The pond piezometers No. 4 and No. 1 contained sufficient water for chemical analysis piezometer No. 4 water showed somewhat increased concentration of sodium, chloride, sulfate and boron. The water in piezometer No. 1 was of better quality than No. 4.

Since only one water chemistry sample was collected during 1980 from each sour water pond, only rough data are possible. Pond No. 1 exhibited greatly increased conductivities and a possible shift in ion composition from sodium bicarbonate to sulfate. A similar pattern was observed for Pond No. 2. Most of the ponds exhibited decreased salinity levels in January, which may be due to precipitation or sampling problems.

5.4 SUMMARY

The hydrology program provides data necessary to satisfy lease stipulations and conditions of approval from the OSO; assess impacts of dewatering and reinjection (development activities) provide input to engineering design for the mine and water handling system; supply information necessary for environmental disciplines to evaluate impacts and mitigation; and collect data for compliance with permit stipulations. Stream gaging and erosion stations, springs and seeps, alluvial and deep aquifer holes, surface water impoundment, discharges, and reinjection and dewatering wells were monitored.

The results of the hydrology program are summarized below:

- Surface Water - Of the six gaging stations monitored, Dry Fork failed to show any flow during the reporting period. During most of the reporting period, there were no surface discharges.

- Springs and Seeps - Physical data for all springs and seeps fell within baseline ranges with the exception of Station No. 14 on Corral Gulch.

- Alluvial Groundwater - Many of the alluvial wells remained dry throughout the reporting period, a condition similar to that experienced during baseline monitoring. Physical data for the alluvial wells generally fluctuated within baseline ranges.

- Upper and Lower Aquifer Water - Natural recharge to the upper aquifer occurred in the west, northwest and southern portions of the tract.

- Development Activities - A booster pump was installed in Box Elder Gulch to increase the reinjection rate to the south.

LITERATURE CITED

Rio Blanco Oil Shale Company. 1979b. Modular Development Phase Monitoring Report 4, December 1978 - May 1979. Gulf Oil Corporation and Standard Oil Company (Indiana).

SECTION 6

SPECIAL STUDIES

6.1 TOXICOLOGY

1. Objectives

Toxicological studies have been or are being conducted to assess potential health hazards of oil shale-related emissions, effluents, solid wastes, products and combustion products. Specifically, these studies are designed to accomplish the following tasks:

- Determine the biological activity (carcinogenicity, mutagenicity, teratogenicity, and toxicity) of oil shale products and by-products
- Assess the potential worker exposures and environmental hazards
- Provide data to aid in the development of an industrial hygiene program, control procedures and technology to mitigate or prevent worker exposure and environmental hazards

2. Methods

a. API Program - In 1976, the American Petroleum Institute (API) initiated a program to investigate selected toxicological properties of oil shale and related materials. This study included the evaluations shown in Table 6-1. Samples for these tests were collected from oil shale properties throughout the Colorado Plateau and included samples of raw shale from Tract C-a. A detailed discussion of the API program has been published in the American Industrial Hygiene Association Journal (Weaver and Gibson 1979).

b. DOE Program - A Department of Energy (DOE) sponsored toxicology program was initiated in 1980 to collect more detailed, site-specific toxicological data at Tract C-a on raw oil shale and the products and by-products generated by the MIS processing of this shale. These studies included the following:

- Detailed chemical and physical characterization of the source materials, process streams, products and by-products

- Evaluation of potential health effects associated with MIS processing of oil shale

- Biological testing of the compounds and materials associated with MIS processing

c. <u>RBOSC Program</u> - RBOSC has initiated a program to evaluate the toxicological properties of raw oil shale and materials connected with the MIS and Lurgi retorting processes. The tests that will be conducted and the materials involved are shown in Table 6-2. The program has been approved and was initiated in April 1981. Results of the RBOSC program will be reported in subsequent MDP reports as they become available.

Table 6-1. API Oil Shale Materials Toxicology Program Summary

		Materials Tested		
Evaluation or Test	Organism	Raw Shale	Spent Shale	Raw Shale Oil
Acute Oral Toxicity	Rat	X	X	X
Acute Dermal Toxicity	Rabbit	X	X	X
Primary Eye Irritation	Rabbit	X	X	X
Primary Dermal Irritation	Rabbit	X	X	X
Dermal Sensitization	Guinea Pig	X	X	X
Mutagenesis (Ames Assay)	---	X	X	X
Mouse Lymphoma Assay	---	X	X	X
Cytogenetics Assay (Rat Bone Marrow)	---	X	X	X
Teratology	Rat	X	X	X
Chronic Inhalation Toxicity	Rat, Monkey	X	X	X
Chronic Dermal Carcinogenesis	Mouse	X	X	X

Table 6-2. RBOSC Toxicology Program

Test Material	Acutes					Reproductive		Genetic			
	Oral Tox.	Eye Irri.	Skin Irrit.	Dermal Tox.	Skin Sensitization	Inhalation	Dermal	Ames Assay	DNA Syn.	Forward Mutation Assay	Cyto-Genetics
Raw MIS Shale Oil	x	x	x	x	x	0	0	x	x	x	x
MIS Retort Water	x	x	x	x	x	0	0	x	x	x	x
Raw Shale Dust	x	0	0	x	0	0	0	x	x	x	x
MIS Recirculated Retort Water	x	x	x	x	x	0	0	x	x	x	x
Lurgi Retort Water	x	x	x	x	x	0	0	x	x	x	x
Lurgi Processed Shale	x	x	0	x	0	0	0	x	x	x	x
Lurgi Shale Oil (Light)	x	x	x	x	x	Z	x	x	x	x	x
Lurgi Shale Oil (Middle)	x	x	x	x	x	0	x	x	x	x	x
Lurgi Shale Oil (Heavy)	x	x	x	x	x	0	x	x	x	x	x

x = Study Planned

0 = No Study Planned

Z = Study Postponed Until Materials Are Available

3. Results

a. API Program - The results of the API studies are summarized in Table 6-3. All of the studies have been completed with the exception of the chronic dermal carcinogenesis studies, for which interim results are included. In the inhalation studies, rats and monkeys exposed to raw and processed shale dust at concentrations of 10 and 30 mg/m^3 for 2 years showed no evidence of carcinogenesis or progressive fibrotic lung disease from either material. Dermal application of raw oil shale and processed shales resulted in no evidence of carcinogenesis when applied to mice at a dosage of 50 mg twice weekly for a lifetime (approximately 2 years). Similar tests using raw shale oil showed, however, that the raw oil was highly carcinogenic. Tests using refined and semi-refined products were initiated in August 1979. Results of these tests are not available presently but it is anticipated that the refining steps will significantly reduce the carcinogenic and toxic properties of the raw shale oil (Weaver and Gibson 1979).

Tests of raw and processed shale, and crude shale oil to determine teratogenic effects on pregnant rats showed no deformities, although some fetal toxicity was seen in rats exposed to the higher dosages of crude retort oil tested.

All of the raw shale oil samples yielded positive results for mutagenicity in the bacterial assays (Ames test), were either weakly positive or negative for mutagenicity in the mouse lymphoma assay, and showed no mutagenic tendencies in the cytogenetic bioassay. Histopathological studies of the test organisms exposed to toxic concentrations of crude shale oils revealed extensive liver damage resulting from both oral and dermal administration of the oil.

b. DOE Program - The tests conducted under the DOE Toxicology Program have been completed, but the results are not available as yet. These results will be reported by the DOE Oil Shale Task Force.

c. RBOSC Program - The tests conducted under the RBOSC Toxicology Program are in progress. Results will be reported as they become available.

Table 6-3. Results of API Toxicology Studies Involving Oil Shale Materials

RAW SHALE

Completed Studies	Species	Results
Acute Oral Toxicity	Rat	LD_{50}>10g/kg for all samples[1/]
Acute Dermal Toxicity	Rabbit	No systemic toxicity No dermal irritation
Primary Eye Irritation	Rabbit	Non-irritating
Primary Dermal Irritation	Rabbit	Non-irritating
Dermal Sensitization	Guinea Pig	Non-sensitizing
Mutagenesis (Ames Assay)	---	Negative
Mouse Lymphoma Assay	---	Slightly positive, but no significant increase in mutations observed at the higher dose levels.
Cytogenetics Assay (Rat Bone Marrow)	---	Subchronic dose group at 5000 mg/kg showed a significant increase in chromosomal abnormalities. At intermediate dose (1670 mg/kg) abnormalities were high, but not significant. Negative at all other levels.
Teratology	Rat	Negative
Chronic Inhalation Toxicity	Rat, Cynamalogous Monkey	No evidence of either progressive logous monkey fibrogenic, or carcinogenic effects (at 30 mg/m^3) in either species despite clear indication of a lung burden which caused inflammatory reactions in both species.

Studies in Progress	Species/Strain	Interim Results
Chronic Dermal Carcinogenesis	C3H/HeJ Mouse	Non-carcinogenic (no tumor incidence)

Table 6-3. (Continued)

SPENT SHALE

Completed Studies	Species	Results
Acute Oral Toxicity	Rat	LD_{50}>10g/kg for all samples[1/]
Acute Dermal Toxicity	Rabbit	Negative
Primary Eye Irritation	Rabbit	Either significantly irritating but reversible, or non-irritating
Primary Dermal Irritation	Rabbit	Non-irritating
Dermal Sensitization	Guinea Pig	Non-sensitizing
Mutagenesis (Ames Assay)	---	Negative
Mouse Lymphoma	---	Negative
Cytogenetics Assay (Rat Bone Marrow)	---	Negative
Teratology	Rat	Negative
Chronic Inhalation Toxicity	Rat	No evidence of either progressive fibrogenic, or carcinogenic effects (at 30 mg/m^3) in either species despite clear indication of a lung burden which caused inflammatory reactions in both species.

Studies in Progress	Species/Strain	Interim Results
Chronic Dermal Carcinogenesis	C3H/HeJ Mouse	Non-carcinogenic (no tumor incidence

Table 6-3. (Continued)

RAW SHALE OILS

Completed Studies	Species	Results
Acute Oral Toxicity	Rat	LD_{50} of 8.0 - 10.0 g/kg[1/]
Acute Dermal Toxicity	Rabbit	LD_{50}>10 ml/kg for all samples[1/]
Primary Eye Irritation	Rabbit	Moderate, reversible irritation
Primary Dermal Irritation	Rabbit	Moderate, reversible irritation
Dermal Sensitization	Guinea Pig	Non-sensitizing
Mutagenesis (Ames Assay)	---	Positive with microsomal activation
Mouse Lymphoma Assay	---	Weakly positive or negative; varies with sample
Cytogenetics Assay (Rat Bone Marrow)	---	Negative
Teratology	Rat	Negative

Studies in Progress	Species/Strain	Interim Results
Chronic Dermal Carcinogenesis	C3H/HeJ Mouse	Tumor incidence = 81-87% Average latency period = 21.6-31.9 weeks

1/ LD_{50} = Dosage at which 50 percent of test animals expire.

6.2 REVEGETATION

RBOSC continues to revegetate and/or temporarily stabilize disturbed areas after operational activities have ceased. During the reporting period, areas adjacent to the booster pump station in Box Elder Gulch and topsoil stockpile B in Corral Gulch were seeded and mulched. The booster pump station was reseeded (mix #1) and hydromulched in those areas where construction activities and/or recontouring activities resulted in redisturbance during the winter months. The topsoil stockpile was recontoured after the addition of topsoil from the Lurgi access road. Stabilization was not possible until late in May; therefore, the area was seeded with stubble mulch species (winter rye plus some barley) and was hay mulched to reduce wind erosion prior to establishment of the grass species.

6.3 SUBSIDENCE MONITORING (MIS Area)

1. Objectives

Subsidence monuments were installed and are measured on a periodic basis to establish any surface displacement due to dewatering, retort preparation, the burning of the retorts, or other causes.

2. Methods

A survey monument grid was placed on the ground surface over each MDP retort area prior to its rubblization. Additional monuments were placed in various other areas to determine the effects of dewatering. All monuments consist of a one-inch rebar pin anchored with resin inside a three-inch casing. The coordinates and elevation of each of the monuments were established and reported in MDP Monitoring Report 4 (RBOSC 1979b). RBOSC determined the horizontal and vertical relationship of these monuments to a primary control point sufficiently distant from the retorts to assure that this primary control point does not itself undergo any horizontal or vertical displacement due to MIS activities.

During surveys conducted every six months, all monuments are checked for vertical movement relative to a secondary control point at the intersection of the old Airplane Ridge Road and the main access road. The reason that this control point was selected was to reduce the time required for routine checking of the monuments, since it is considerably closer to the site than the primary control point which is located south of the MIS area. If movement is noted during the six-month surveys, then a check from primary control will be necessary to insure that the secondary control has not moved. If substantial movement is confirmed, the topography of the affected area will be re-mapped in appropriate detail by plane table or other suitable means. Third order surveying accuracy control is used for all vertical and horizontal control work.

As of June 1979, 50 monuments were in existence. Construction activities subsequently destroyed six monuments, leaving 44 monuments as of December 1980. These monuments are currently monitored (Figure 6-1).

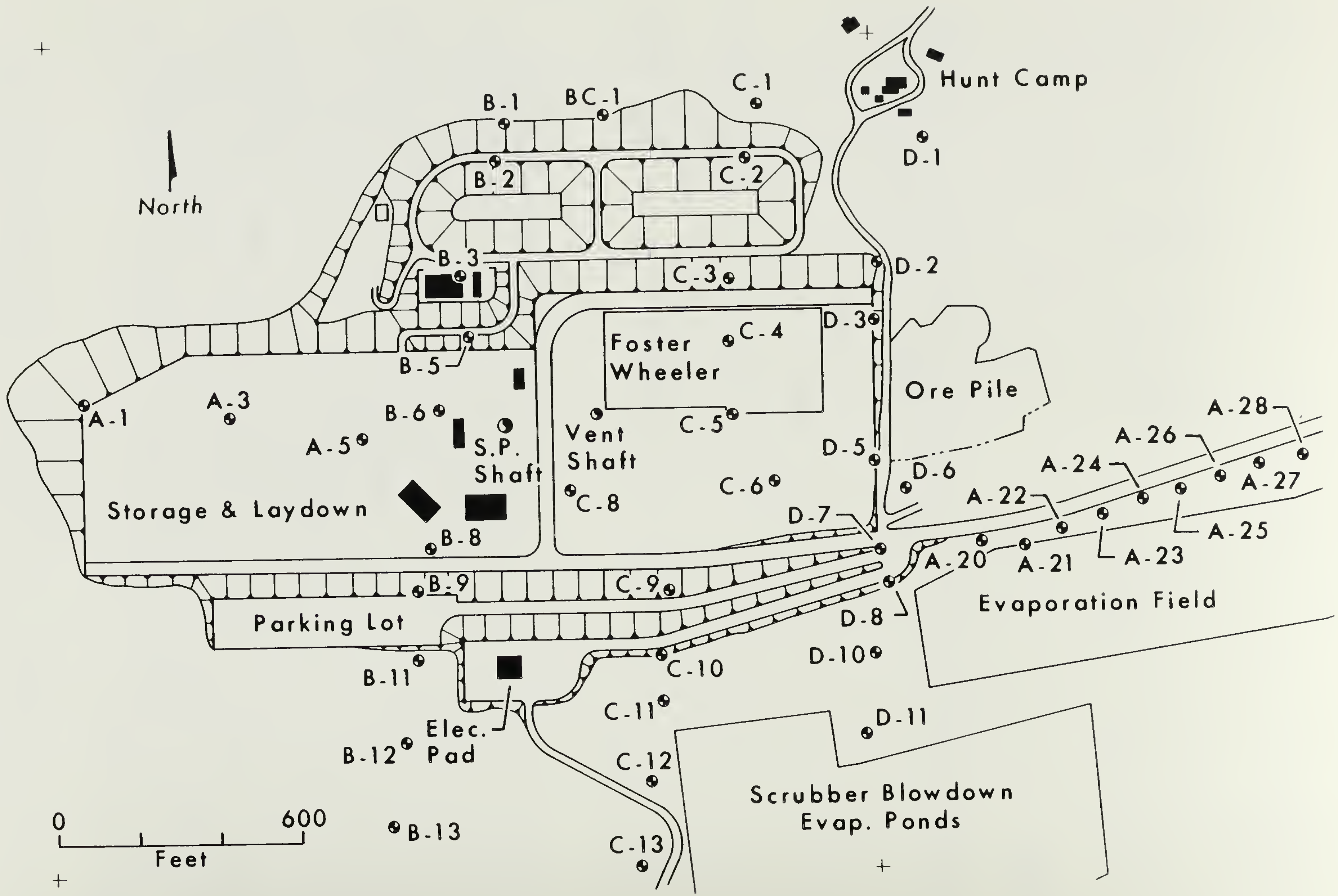

Figure 6-1 Subsidence Monument Location Map

3. Results

During June of 1981, vertical surveys were conducted on 44 monuments. No monument movement was detected in this survey, except in the case of monuments A-1 and B-6, which were disturbed by construction. These monuments were re-established in the same location, and a new base elevation was determined for use in future surveys.

6.4 RUN-OF-MINE LYSIMETER STUDY

RBOSC, in cooperation with the EPA, USGS and the DOE Task Force, is conducting leaching studies on stockpiled run-of-mine ore. As a part of this agreement, RBOSC constructed the leaching apparatus in the stockpile. The cooperating government groups will collect and analyze the leachate.

The objective of this study is to determine the chemical characteristics of leachate generated from raw shale in the field and to compare these results with those from laboratory tests on the same materials. This comparison is being conducted to determine the importance of such factors as percolation rates (residence times), wetting and drying cycles, and other weathering factors on leachate quality.

The field collection system consists of three collectors buried beneath the raw shale pile at depths of 5, 10, and 15 feet. Each collector consists of a 10 x 10 foot square teflon sheet, contoured so that the percolating water is intercepted and conducted to a teflon drain pipe located at the center of the collector (Figure 6-2). Collectors are constructed so that leachate is collected sequentially in a series of five containers (three 2-liter and two 40-liter). As one container is filled, leachate is routed to the next container in the sequence.

A flow-through electrical resistance probe and a thermocouple have been placed in the teflon collection line to measure conductivity and temperature. Recording rain gages document precipitation quantity in the area of the pile. Snow depths are periodically recorded.

The field lysimeter tests were initiated in mid-June, 1980. The cumulative leachate volumes which have been collected at each depth since that time are listed in Table 6-4. An intense rainfall event on August 15, 1980 resulted in leachate accumulation in the 5-foot collector. No significant leachate volume accumulated in any of the other collectors until Spring, 1981. The data in Table 6-4 suggest that substantial volumes of infiltrated water are being retained in the shale profile. This may be the result of grain size of the material involved.

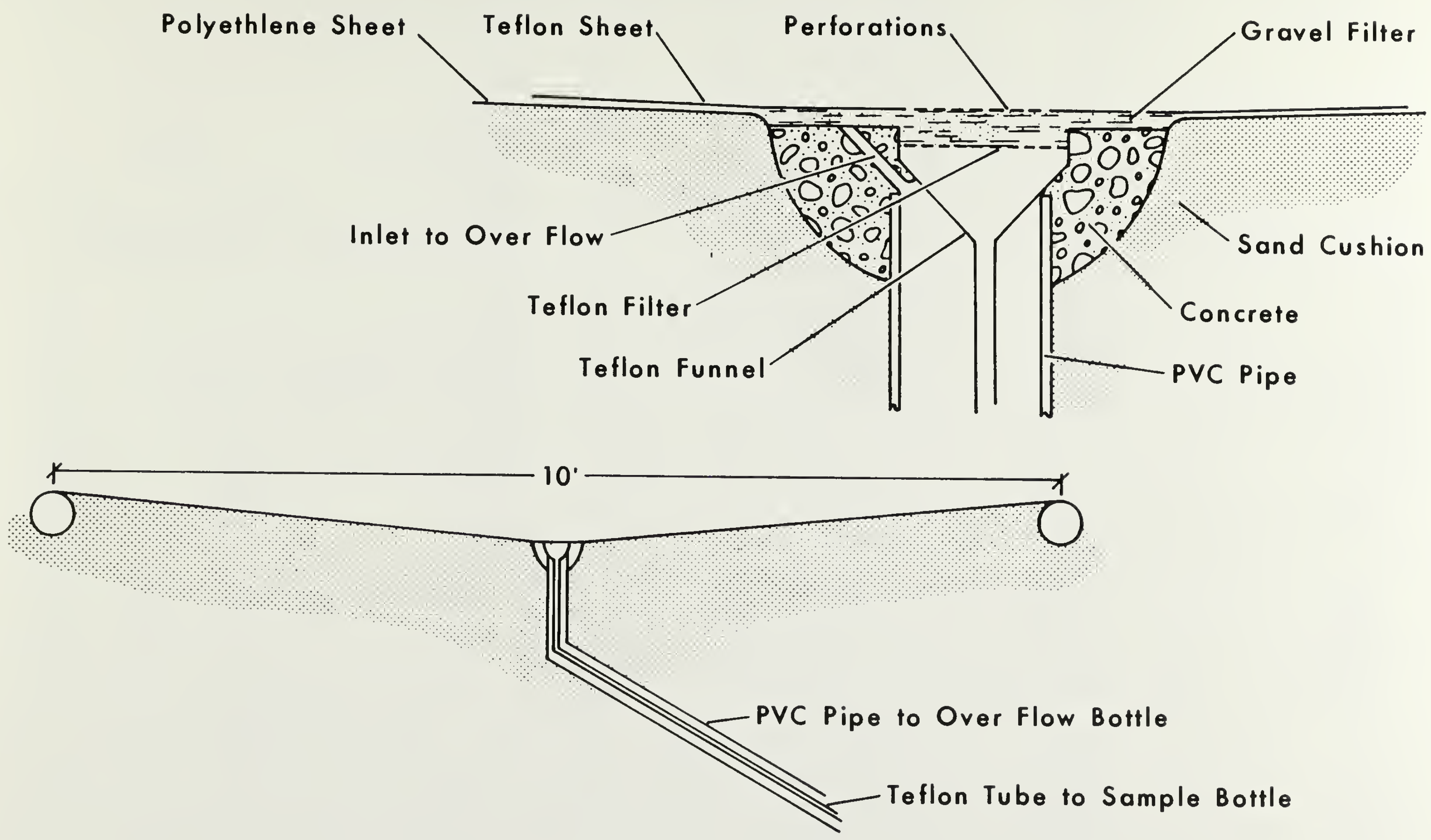

Figure 6-2 Construction Details of the Buried Collectors - Tract C-a.

Table 6-4. Cumulative Leachate Volumes Collected from Run-of-Mine Lysimeter, Tract C-a

	Cumulative Volume					
Collector Depth (Ft)	8/26/80	4/3/81	4/8/81	5/5/81	5/7/81	5/29/81
5	6	8	36.7	103.2	105.9	109.9
10	-	-	-	1.95	2.0	2.05
15	-	-	-	3.95	5.95	7.95

Source: McWhorter, David B. Field Leaching Study of Raw Mined Oil Shale, First annual progress report. Reporting period 4-1-80 to 5-31-81. Agricultural and Chemical Engineering Department, Colorado State University, Fort Collins, Colorado 80523.

Leachate samples have been subjected to chemical analysis. The results of chemical analyses completed to date are shown in Tables 6-5 and 6-6. Table 6-5 lists field measurements of electrical conductivity (adjusted to 25°C). Table 6-6 lists the results of a number of additional analyses. The data presented in Table 6-6 under "initial" are the results of analyses of samples from the 5 and 10-foot collectors which were composed of water which was already in the shale at the time of lysimeter placement. As such, these were not strictly "leachates".

Table 6-5. Field Measurements of Electrical Conductivity of Leachates From Tract C-a Lysimeter.

	Electrical Conductivity (mmhos/cm @ 25°C)					
Leachate Source	8/26/80	4/3/81	4/8/81	5/5/81	5/7/81	5/29/81
5-Foot Collector, Bottle A	3.4	6.6	11.8	19.2	21.4	21.6
5-Foot Collector, Bottle B	2.8	-	12.4	17.2	21.4	20.6
5-Foot Collector, Bottle C	3.4	-	-	17.8	-	21.4
5-Foot Collector, Bottle D	4.0	-	-	-	-	-
5-Foot Collector, Bottle E	-	4.2	-	10.6	-	-
10-Foot Collector, Bottle A	-	-	-	12.6	16.0	16.0
15-Foot Collector, Bottle A	18.8	-	-	28.4	31.4	28.4
15-Foot Collector, Bottle B	-	-	-	24.5	-	-

Source: McWhorter (see Table 6-4)

Table 6-6. Chemical Analyses of Leachates From Tract C-a Lysimeter

		Leachate Source					
		5-Foot Collector, Initial	Five Foot Collector 8/26/80				10-Foot Collector, Initial
Parameter	Units	Bottle A	Bottle A	Bottle B	Bottle C	Bottle D	Bottle A
pH	-	7.78	6.49	7.12	7.00	7.15	7.12
EC	mmhos/cm @ 25°C	5.1	3.06	2.47	2.88	3.27	7.0
Alk	mg/l as $CaCO_3$	98	46	43	51	67	75
H_2CO_3	mg/l	5.7	53	12	18	17	20
HCO_3	mg/l	119	56	52	62	82	91
CO_3	mg/l	0.42	0.01	0.04	0.04	0.07	0.07
F	mg/l	2.5	5.0	3.0	3.5	8.1	9.0
Cl	mg/l	175	52	22	24	27	190
NO_3	mg/l	1100	370	100	160	190	2100
SO_4	mg/l	1500	2000	1800	2100	2600	2500
B	mg/l	0.450	0.184	0.128	0.156	0.168	0.637
Cd	mg/l	0.172	0.258	0.143	0.189	0.291	0.260
Be	mg/l	0.0019	0.0027	0.0009	<0.00005	0.0031	0.0077
Mg	mg/l	225	320	324	328	632	552
P	mg/l	0.73	0.52	0.75	0.91	0.58	0.74
Si	mg/l	5.3	3.9	3.2	3.8	3.0	3.5

Table 6-6. (Continued)

		Leachate Source					
		5-Foot Collector, Initial	Five Foot Collector 8/26/80				10-Foot Collector, Initial
Parameter	Units	Bottle A	Bottle A	Bottle B	Bottle C	Bottle D	Bottle A
Mo	mg/l	4.7	1.3	0.78	0.89	0.91	5.8
Mn	mg/l	0.086	0.248	0.156	0.213	0.239	0.269
Ni	mg/l	0.08	0.11	0.11	0.17	0.15	0.31
Na	mg/l	1370	376	232	196	363	2820
Cu	mg/l	0.013	0.014	0.016	0.018	0.019	0.025
Al	mg/l	1.9	2.0	2.1	2.5	2.4	2.3
Ca	mg/l	364	400	431	448	807	891
Ba	mg/l	0.061	0.099	0.083	0.089	0.073	0.099
K	mg/l	12	6.9	3.3	3.3	4.7	15
Cr	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	0.13
Sr	mg/l	4.7	4.0	2.9	3.1	3.5	5.9
Pb	mg/l	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

Source: McWhorter (See Table 6-4)

In general, conductivities have increased rapidly over time for a given collector and bottle. The latest samples showed conductivities of 20 mmhos/cm and above (No data from the in-line EC sensor are reported because the maximum range of the sensor is 13 mmhos/cm. The sensor has been modified to enable the measurement of higher EC values).

Averaged results from Table 6-6 are compared with results of two laboratory leaching tests of C-a shale and with Colorado Department of Health Domestic Water Supply Standards in Table 6-7. Generally, the concentration of constituents in the field lysimeter samples was lower than or in the range of values reported from the laboratory tests. This may be due, in part, to the difference in the size fractions of materials used in the two respective tests. For the laboratory tests, the shale was crushed to approximately one inch nominal diameter. Field tests were on run-of-mine material having a nominal diameter of about two inches. Thus, the surface area per unit weight would be greater for test materials in the lab test than in the field studies. Consequently, the more concentrated leachates from the laboratory test may have resulted from greater contact of the leaching medium (deionized water) with the test material.

Comparison of the lysimeter data with Colorado domestic water supply standards shows that concentrations of trace metals except manganese are below the drinking water limitations. Due to analytical limitations, it is not possible to determine if chromium and lead concentrations are below standards.

Although the concentrations of nitrate, sulfate, and fluoride exceed drinking water standards, the concentrations of these anions in the leachate are similar to those found in lower aquifer waters in the region. These concentrations would not pose a serious water pollution problem if leachate entered the natural surface or subsurface hydrologic system.

Table 6-7. Comparison of Field Lysimeter Data with Laboratory Data and Drinking Water Standards

Parameter	Units	C-a Lysimeter Study[1/] (Average Value)	C-a R-5/Mahog. Shale (Laboratory Test)	C-a Composite (Laboratory Test)	Colorado Domestic Water Supply Standards
Al	mg/l	2.2	0.3 - 3.53	<0.05 - 0.69	---
B	mg/l	0.287	<0.025 - 0.59	<0.025 - 1.97	---
Ba	mg/l	0.084	0.088 - 0.27	0.027 - 0.22	1.0
Be	mg/l	0.0027	<0.025	<0.025	---
Ca	mg/l	423	180 - 1510	18 - 970	---
Cl	mg/l	82	1.9 - 300	0.3 - 130	---
CO_3	mg/l	0.108	<0.1 - 346	0.3 - 0.7	---
Cr	mg/l	<0.1[2/]	0.022 - 0.034	<0.025 - 0.043	0.05
Cu	mg/l	.018	<0.025 - 0.69	<0.025 - 0.44	1.0
EC	µmhos/cm	3963	1900 - 37000	125 - 8200	---
F	mg/l	5.18	0.8 - 65	<0.5 - 3.0	1.8
HCO_3	mg/l	77	3.0 - 403	82 - 1026	---
K	mg/l	7.53	8.2 - 640	0.4 - 34	---
Mg	mg/l	397	0.675 - 108	4.9 - 820	---
Mn	mg/l	0.201	<0.05 - 0.35	<0.05 - 0.40	0.05

Table 6-7. (Continued)

Parameter	Units	C-a Lysimeter Study[1/] (Average Value)	C-a R-5/Mahog. Shale (Laboratory Test)	C-a Composite (Laboratory Test)	Colorado Domestic Water Supply Standards
Mo	mg/l	2.4	0.10 - 5.18	0.10 - 2.2	---
Na	mg/l	893	27 - 7710	4.3 - 1240	---
NO_3	mg/l	670	4 - 172	<0.5 - 140	10
Pb	mg/l	<0.3[2/]	<0.05 - 0.83	<0.05 - 0.77	0.05
pH	---	7.11	6.93 - 11.98	7.03 - 7.99	---
Si	mg/l	3.78	1.2 - 23.28	5.8 - 19.58	---
SO_4	mg/l	2083	5 - 6600	7.9 - 6100	250

1/ Average of all data from Table 6-6

2/ Detection limit

SECTION 7

ECOLOGICAL INTERACTIONS

7.0 ECOLOGICAL INTERACTIONS

There are a large number of interactions that could be expected to occur within the aquatic ecosystems of the Tract C-a area. This report will concentrate on two aspects of the aquatic ecology dynamics that are of particular interest. They are:

- Seasonal changes in stream water quality at Aquatic Station CG-1.

- Seasonal changes in macroinvertebrate taxon and density estimates for all stations sampled.

Although the aquatic ecosystem is subject to many more interactions than the two identified above, these two have been selected for discussion because sufficient data has been collected to show patterns in the seasonal cycle. In addition, these two factors appear to be related.

7.1 SEASONAL CHANGES IN STREAM WATER QUALITY AT AQUATIC STATION CG-1

Aquatic sampling station CG-1 is located in Corral Gulch near gaging station D and the air studies monitoring tower (Met Site 3). Aquatic samples have been collected at this station since October 1974. CG-1 would be the first station affected by any impact resulting from the development of Tract C-a.

Changes in water quality can result in changes in the biotic population of a given area. Specifically, temperature, conductivity, dissolved oxygen, alkalinity, and pH are general measures of water quality which also influence biotic populations. Seasonal variability in the above parameters needs to be understood if changes in the biotic community are to be fully understood.

The seasonal and yearly variability in the above five water quality parameters at aquatic station CG-1 has been examined. Figures 7-1 through 7-3 show the seasonal variation in the five parameters between 1975 and 1980. These figures do not show any definate long term trends in water quality; however, it is evident that there is a high degree of natural and seasonal variability in these parameters.

Temperature has been demonstrated to be a limiting factor in the biotic community structure (Hardy 1961). Thus, seasonal changes in water temperature at Station CG-1 can be expected to produce seasonal changes in the community structure of aquatic biota. A two-way analysis of variance (ANOVA) technique was applied to these data using temperature as the dependent variable and years and seasons as the independent variables, to examine the yearly and seasonal variabilities that might affect the biotic community at CG-1. Results of this analysis show that a significant interaction between years and seasons exists for the period from 1975 to 1980 (Table 7-1). A Duncans Multiple Range Test was performed on the significant main effects, years and seasons (Table 7-2). This test shows a high degree of variability in water temperature means over the six year period, along with a distinct seasonal temperature pattern. The mean summer temperatures were two degrees higher than the spring and fall seasons. This pattern of seasonal temperatures should be expected to influence the population dynamics of the biota at CG-1.

Conductivity is a general measure of the salinity of water. Salinity influences the biochemical process of aquatic biota by limiting the transport of life supporting ions through the various membranes (Potts 1968). Conductivity levels at CG-1 have been examined to determine if seasonal or yearly variabilities are influencing the community structure of aquatic biota (Figure 7-2). A two-way ANOVA was used to determine the seasonal and yearly behavior of the conductivity data since 1975 (Table 7-1). Results show that there is a significant (α=0.05) year by season interaction term. A test of the main effect means, using the conservative Duncan's Multiple Range test, indicates that a very high degree of year to year variability exists for the conductivity data while no detectable variability exists for the main effect season (Table 7-3). These results indicate that conductivity may not be a primary water quality parameter affecting the aquatic biota at CG-1 on a seasonal basis.

Dissolved oxygen, alkalinity, and pH are three water quality parameters that may affect the community structure at CG-1. Seasonal changes in any of these three parameters can effect the aquatic biota by altering the ion balance required to support aquatic life (Prosser 1975). Discharge into Corral Gulch may alter the water quality of this stream. The two-way ANOVA was applied to each of the three dependent variables, with years and seasons being the independent effects in question (Table 7-1). In all cases, the year by season term and the main effect terms were nonsignificant (α=0.05) indicating that very little detectable year to year and seasonal variability has occurred at this station. The assumption should then be made that, because there is no yearly or seasonal variability in dissolved oxygen, alkalinity, or pH, tract development is not significantly affecting these water quality parameters.

Table 7-1. Results of the Two-Way Analysis of Variance Tests Comparing Years and Seasons for Water Quality Parameters measured at Aquatic Station CG-1.

Dependent Variable	Degrees Of Freedom[1/]	Source	Sums Of Squares	F Value	PR>F[2/]
Temperature	5	Years	65.99	3.77	0.0311
	2	Seasons	32.34	4.62	0.0349
	8	Years x Seasons	89.24	3.19	0.0393
	11	Error	38.50		
Conductivity	5	Years	512465.33	7.23	0.0032
	2	Seasons	21368.17	0.75	0.4933
	8	Years x Seasons	401366.66	3.54	0.0280
	11	Error	155841.83		
Dissolved Oxygen (DO)	5	Years	6.49	0.38	0.8534
	2	Seasons	8.87	1.29	0.3134
	8	Years x Seasons	8.34	0.30	0.9491
	11	Error	37.79		
Alkalinity	5	Years	38313.74	1.39	0.3001
	2	Seasons	16540.05	1.50	0.2650
	8	Years x Seasons	78708.44	1.79	0.1834
	11	Error	60565.16		
pH	5	Years	2.62	1.27	0.3447
	2	Seasons	0.55	0.66	0.5340
	8	Years x Seasons	1.38	0.42	0.8880
	11	Error	4.55		

1/ N = 27
2/ RR>F = Probability of obtaining a greater F value.

Table 7-2. Results of Duncan's Multiple Range Tests for Significant Main Effect Differences in Years and Seasons for the Dependent Variable Temperature at Aquatic Station CG-1

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE TEMP

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=11 MS=3.5

GROUPING			MEAN	N	YEAR
	A		19.000000	1	1977
	A				
B	A		15.333333	6	1979
B	A				
B	A		15.250000	4	1976
B	A				
B	A	C	14.200000	5	1975
B		C			
B		C	13.600000	5	1978
		C			
		C	12.000000	6	1980

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE TEMP

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=11 MS=3.5

GROUPING		MEAN	N	SEASON
	A	15.076923	13	SUMMER
	A			
B	A	13.714286	7	FALL
B				
B		13.000000	7	SPRING

Table 7-3. Results of Duncan's Multiple Range Tests for Significant Main Effect Differences in Years and Seasons for the Dependent Variable Conductivity at Aquatic Station CG-1

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE SP_COND

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=11 MS=14167.4

GROUPING		MEAN	N	YEAR
	A	1560.000000	5	1978
	B	1386.000000	5	1975
	B			
	B	1320.833333	6	1980
	B			
C	B	1223.833333	6	1979
C	B			
C	B	1200.000000	1	1977
C				
C		1137.500000	4	1976

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE SP_COND

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=11 MS=14167.4

GROUPING	MEAN	N	SEASON
A	1346.428571	7	FALL
A			
A	1342.153846	13	SUMMER
A			
A	1267.857143	7	SPRING

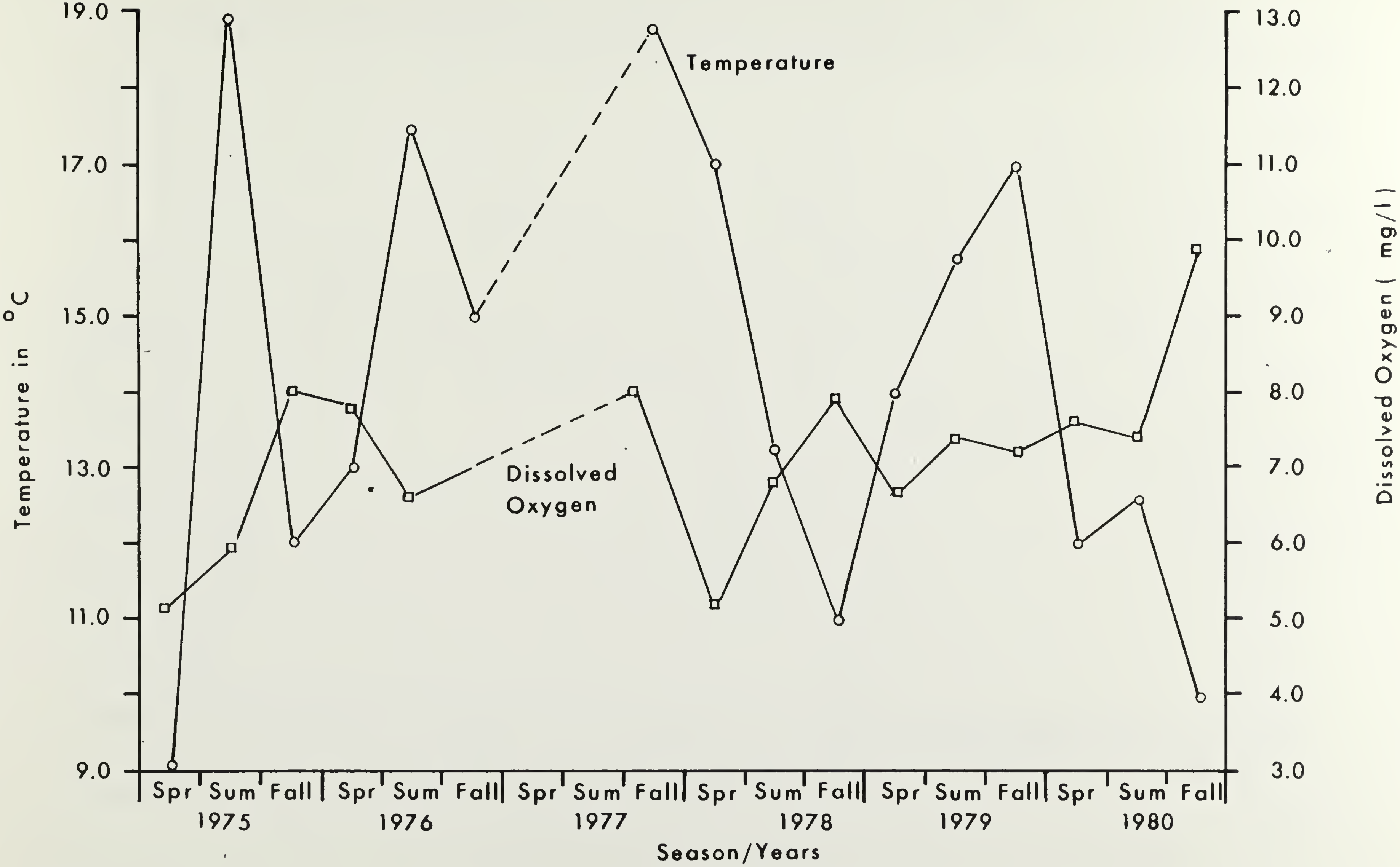

Figure 7-1. Seasonal Changes in Surface Temperature and Dissolved Oxygen at Aquatic Station CG-1, 1975-1980.

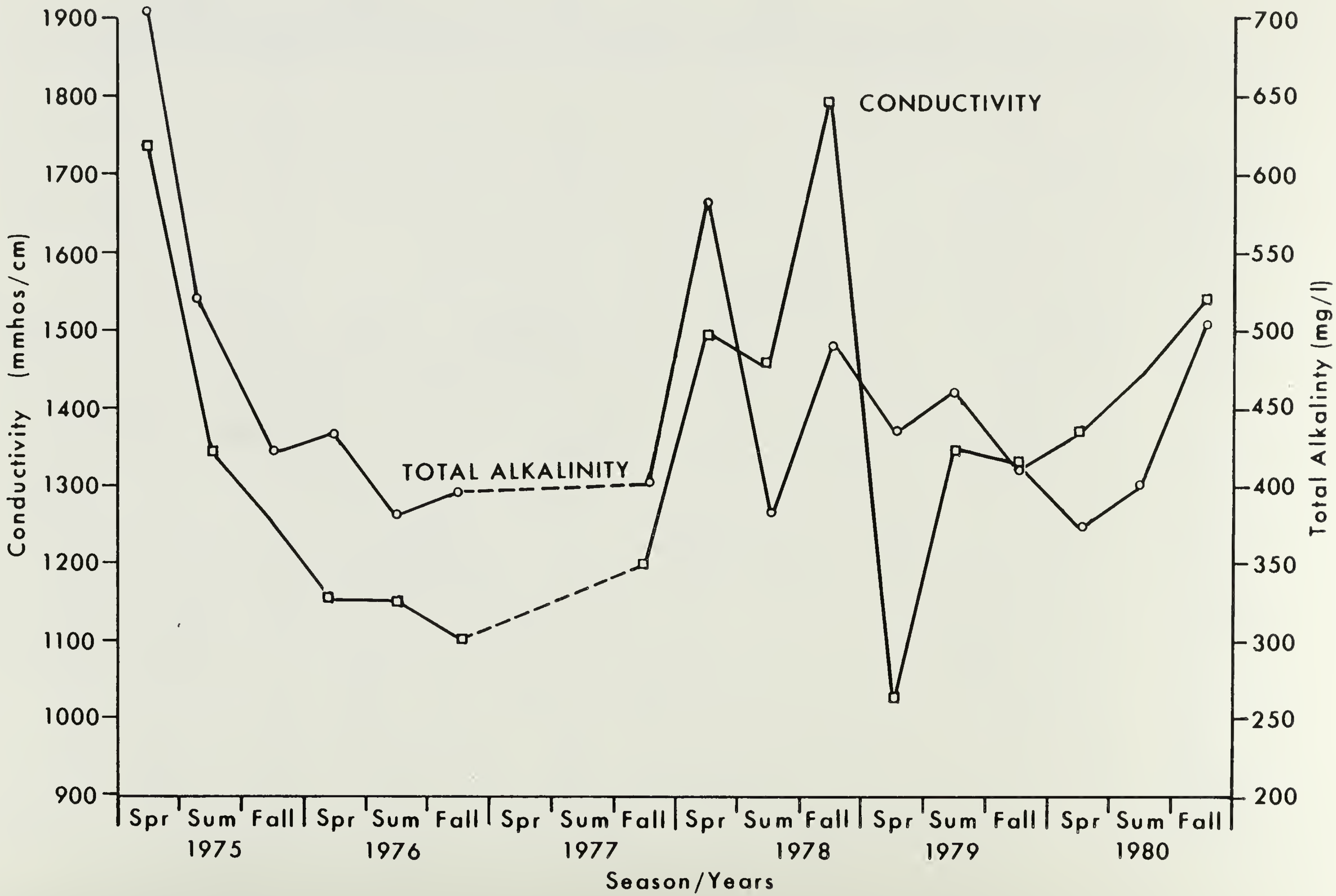

Figure 7-2. Seasonal Changes in Conductivity and Total Alkalinity at Aquatic Station CG-1,1975-1980.

Figure 7-3 Seasonal Changes in pH at Aquatic Station CG-1, 1975-1980

7.2 SEASONAL CHANGES IN MACROINVERTEBRATE TAXON AND DENSITY ESTIMATES

Seasonal changes in the community structure of macroinvertebrates, sampled at six stations along Corral Gulch, Yellow Creek, and the White River were analyzed to evaluate natural variability. Macroinvertebrates are the major consumers in the aquatic ecosystems of the study area and, thus, are subject to natural and man induced pressures that affect the energy flow between trophic levels.

Development of Tract C-a may affect the biotic populations in surrounding aquatic ecosystems. In order to determine if Tract development is affecting the macroinvertebrate community, the natural variability in aquatic ecology (both abiotic and biotic) must be understood. In Section 7.1, the seasonal changes in water quality at aquatic station CG-1 were discussed; the purpose of Section 7-2 is to examine the seasonal changes in major taxonomic orders of macroinvertebrates in the aquatic communities near Tract C-a.

A two-way analysis of variance (ANOVA) technique was utilized to examine the independent effects of year and season against the dependent variable density, for each major taxonomic group. This technique was chosen in conjunction with the analysis used in Section 7.1. Mean seasonal densities for each taxonomic group are shown in Figures 7-4 to 7-10. Results of the two-way ANOVA tests are presented in Tables 7-4 to 7-10. It is difficult to determine any long term trends in seasonal occurence of the major benthic taxa; however, there is a high degree of seasonal variability in these taxa (Figures 7-5 to 7-10).

Chironomids (Midges: Family Chironomidae) are members of the Order Diptera (Flies and Mosquitoes). All the chironomid species encountered in the aquatic ecosystems of Tract C-a are holometabolous; most organisms collected were in the larval and pupal stages of development. Chironomids are the second most abundant taxon encountered in the aquatic community near Tract C-a (Figure 7-4). Results of the two-way ANOVA (Table 7-4) indicate no significant differences in Chironomid densities over the years and seasons sampled (Figure 7-4). This may be due in part to the large variability in Chironomid density encountered or a relatively small change in mean seasonal

Table 7-4. Results of Two-Way Analysis of Variance Tests Comparing Years and Seasons with Density Estimates by Major Taxonomic Group.

Dependent Variable (Taxonomic Group)	Degrees Of Freedom[1/]	Source	Sums Of Squares	F Value	PR>F[2/]
Density (Chironomidae)	1	Year	241840.21	0.10	0.7543
	2	Season	2353861.57	0.48	0.6207
	2	Year x Season	9060985.38	1.84	0.1616
	186	Error	457875946.09		
Density (Coleoptera)	1	Year	83.87	0.18	0.6701
	2	Season	331.10	0.36	0.6986
	2	Year x Season	2157.96	2.34	0.0989
	186	Error	85678.86		
Density (Ephemeroptera)	1	Year	1552627.06	1.67	0.1975
	2	Season	6656504.39	3.59	0.0296
	2	Year x Season	2178577.51	1.17	0.3115
	186	Error	172628958.70		
Density (Nematoda)	1	Year	7572.67	5.18	0.0240
	2	Season	3964.10	1.36	0.2602
	2	Year x Season	4680.47	1.60	0.2045
	186	Error	271878.49		

1/ N = 192
2/ PR>F = Probability of obtaining a greater F value.

Table 7-4 (continued).

Dependent Variable (Taxonomic Group)	Degrees Of Freedom[1/]	Source	Sums Of Squares	F Value	PR>F[2/]
Density (Odonata)	1	Year	1649.12	3.10	0.0797
	2	Season	3934.10	3.70	0.0265
	2	Year x Season	4451.60	4.19	0.0166
	186	Error	998798.69		
Density (Oligochaeta)	1	Year	74018234.08	12.55	0.0005
	2	Season	6727924.16	0.57	0.5664
	2	Year x Season	6439509.29	0.55	0.5803
	186	Error	1097311790.27	0.55	
Density (Plecoptera)	1	Year	5089.23	0.42	0.5158
	2	Season	262611.19	10.94	0.0001
	2	Year x Season	96184.51	4.01	0.0198
	186	Error	2232729.45		
Density (Trichoptera)	1	Year	655996.04	1.66	0.1993
	2	Season	3902194.48	4.94	0.0082
	2	Year x Season	1664784.08	2.11	0.1246
	186	Error	73522703.74		

1/ N = 192
2/ PR>F = Probability of obtaining a greater F value.

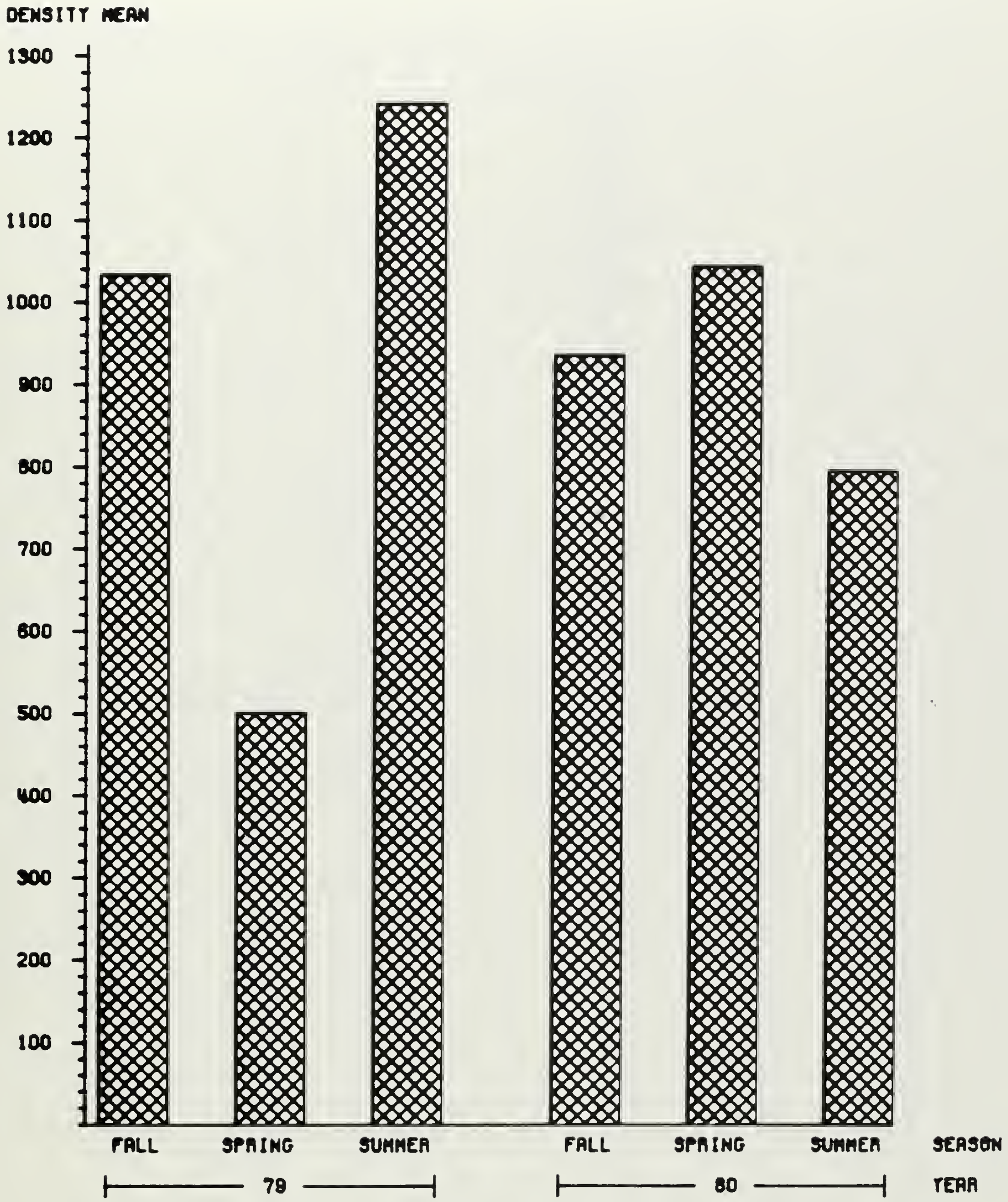

Figure 7-4. Seasonal Changes in Macroinvertebrate Densities (Family Chironomidae), 1979 - 1980.

Table 7-5. Results of Duncan's Multiple Range Test for the Main Effects Year and Season, with the Dependent Variable Density for the Order Ephemeroptera.

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=928113

GROUPING	MEAN	N	YEAR
A	481.220833	96	79
A			
A	301.369792	96	80

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=928113

GROUPING		MEAN	N	SEASON
	A	552.580208	96	SUMMER
	A			
B	A	399.877778	36	FALL
B				
B		128.090000	60	SPRING

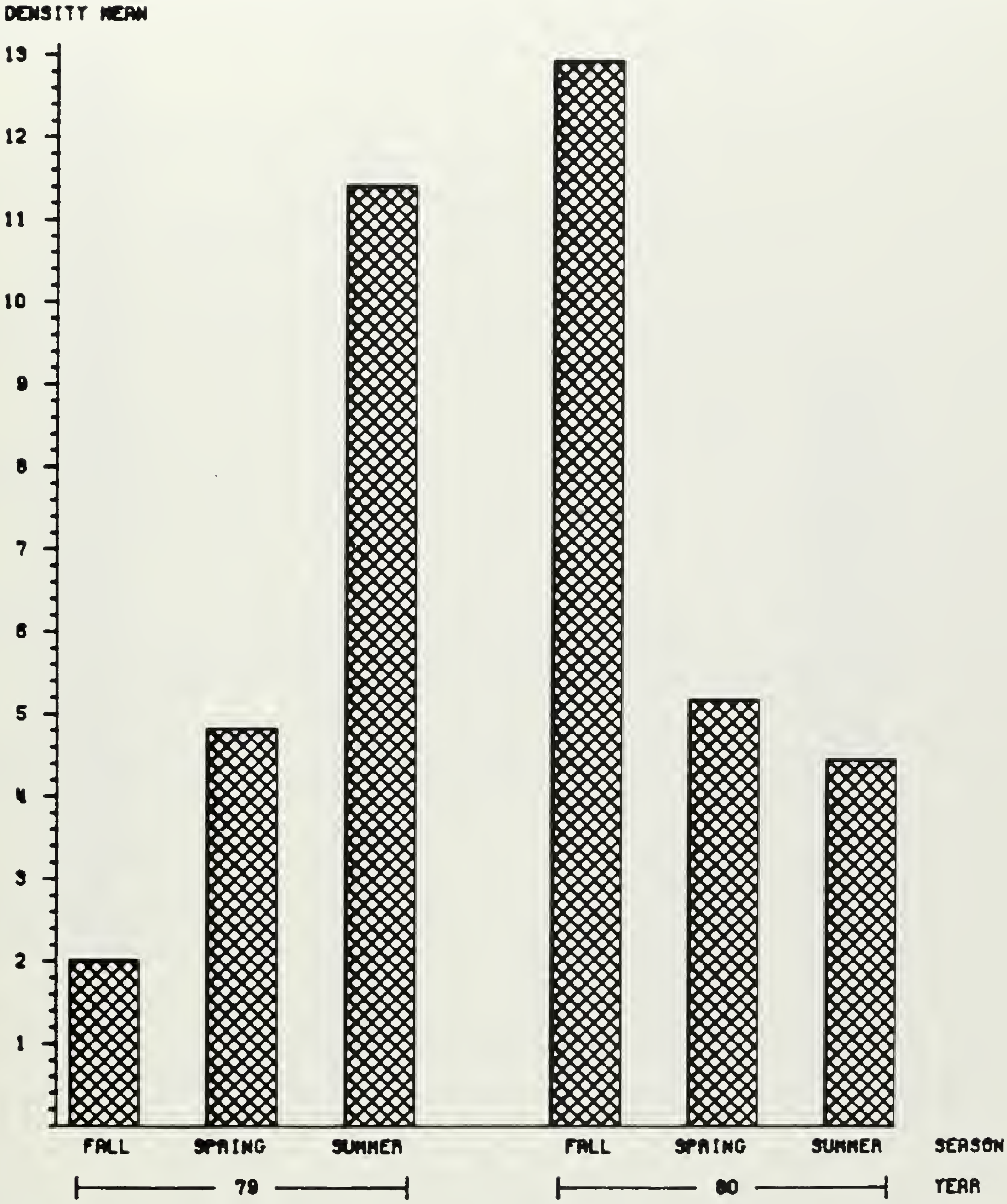

Figure 7-5. Seasonal Changes in Macroinvertebrate Densities (Order Coleoptera), 1979 - 1980.

Table 7-6. Results of Duncan's Multiple Range Test for the Main Effects Year and Season, with the Dependent Variable Density for the Phylum Nematoda.

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=1461.71

GROUPING	MEAN	N	YEAR
A	13.368750	96	79
B	0.808333	96	80

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=1461.71

GROUPING	MEAN	N	SEASON
A	16.547222	36	FALL
A			
A	4.918750	96	SUMMER
A			
A	4.885000	60	SPRING

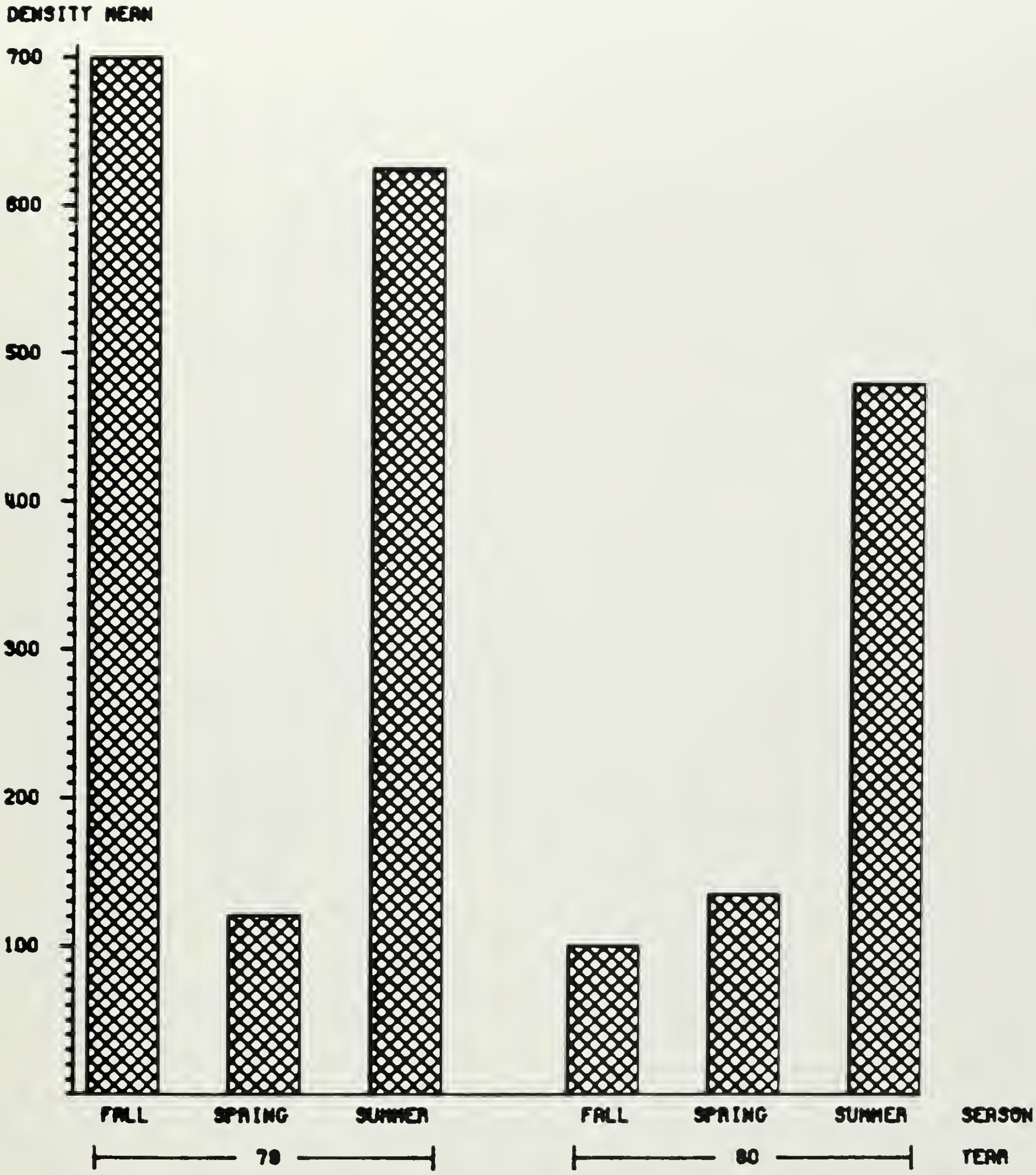

Figure 7-6. Seasonal Changes in Macroinvertebrate Densities (Order Ephemeroptera), 1979 - 1980.

Table 7-7. Results of Duncan's Multiple Range Test for the Main Effects Year and Season, with the Dependent Variable Density for the Order Odonata

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=531.176

GROUPING	MEAN	N	YEAR
A	6.470833	96	80
A			
A	0.609375	96	79

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=531.176

GROUPING	MEAN	N	SEASON
A	12.944444	36	FALL
B	1.618750	96	SUMMER
B			
B	0.971667	60	SPRING

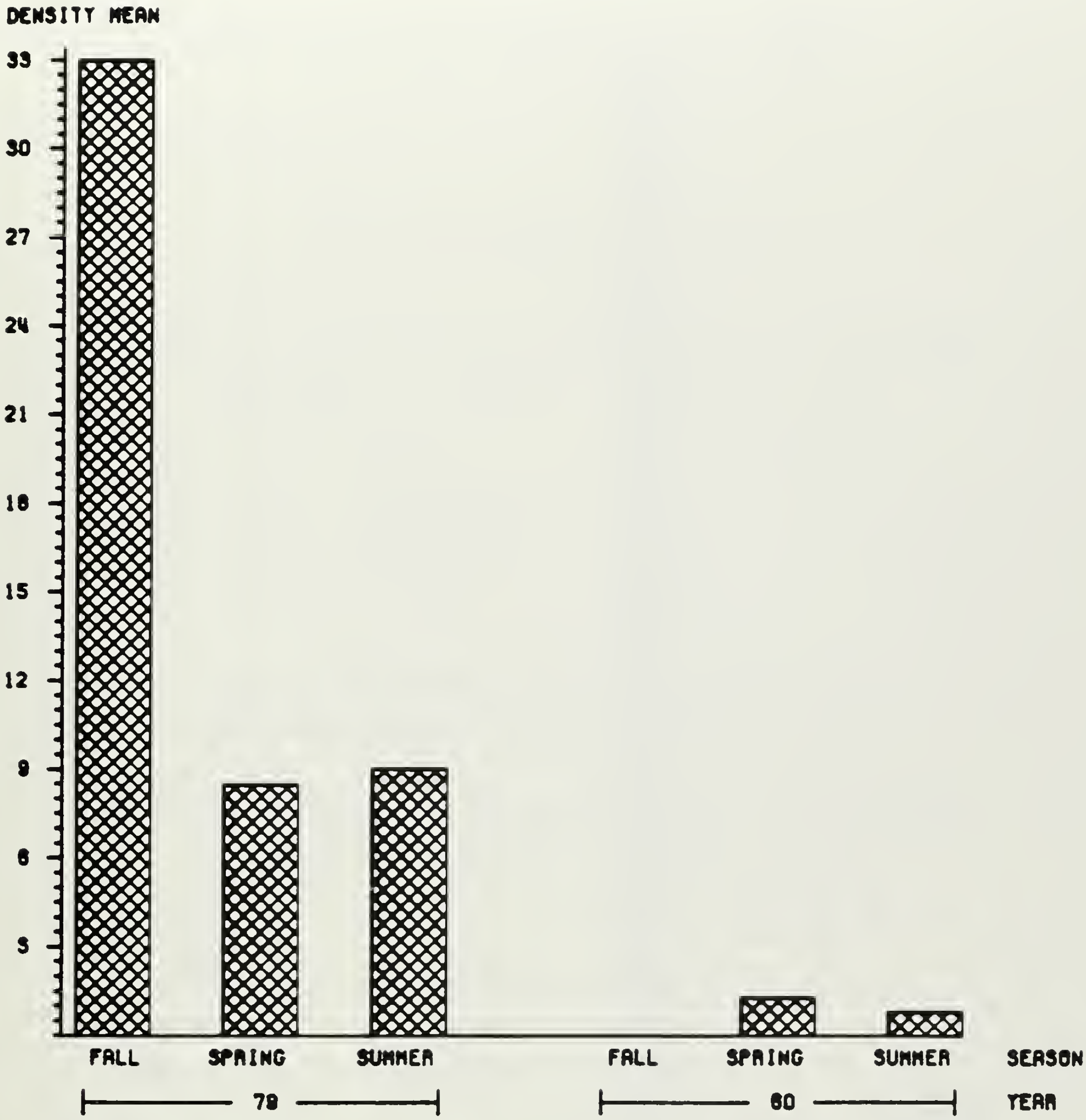

Figure 7-7. Seasonal Changes in Macroinvertebrate Densities (Phylum Nematoda), 1979 - 1980.

Table 7-8. Results of Duncan's Multiple Range Test for the Main Effects Year and Season, with the Dependent Variable Density for the Class Oligochaeta.

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=5899526

GROUPING	MEAN	N	YEAR
A	1355.460417	96	79
B	113.668750	96	80

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=5899526

GROUPING	MEAN	N	SEASON
A	1006.491667	36	FALL
A			
A	789.407292	96	SUMMER
A			
A	483.660000	60	SPRING

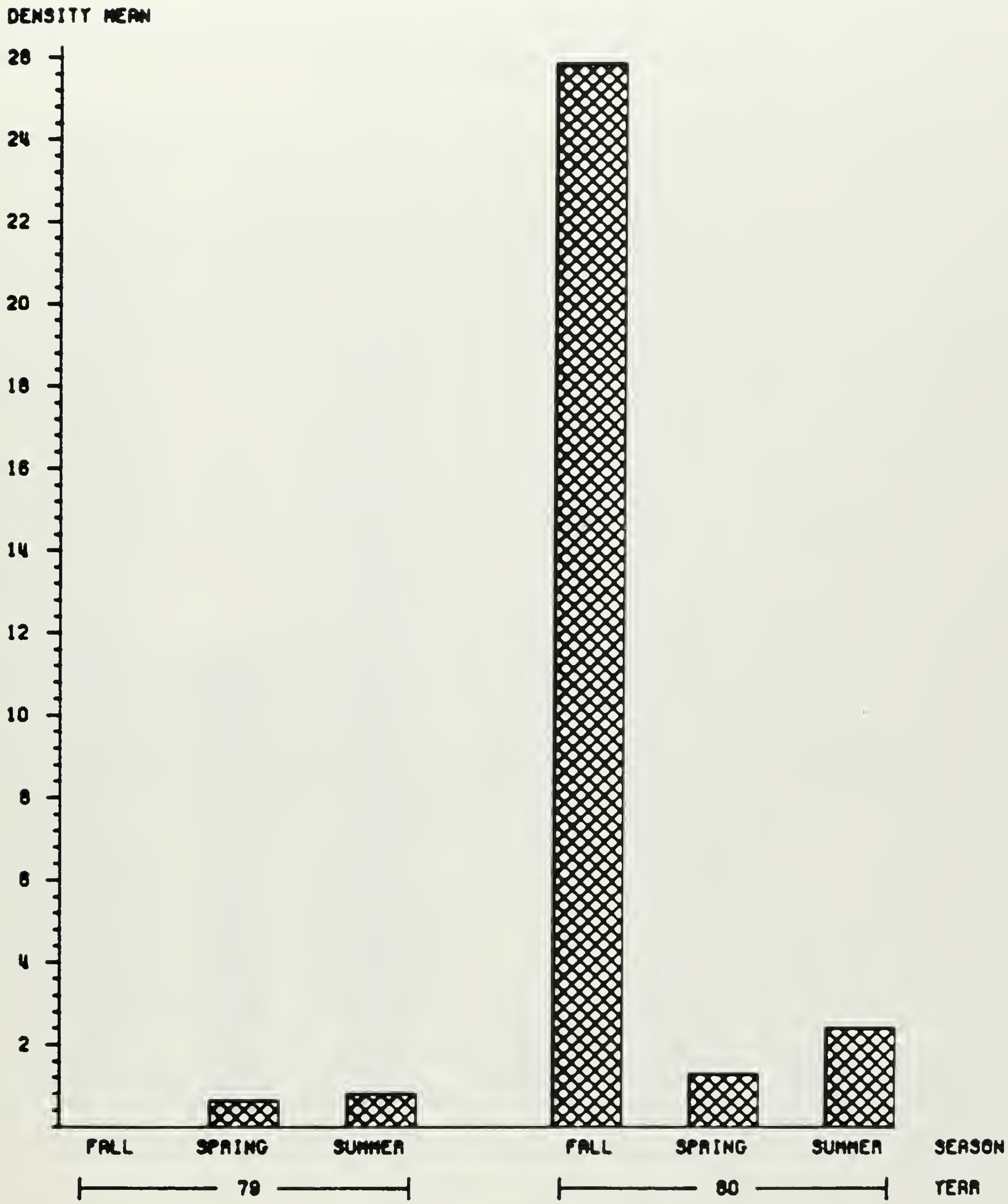

Figure 7-8. Seasonal Changes in Macroinvertebrate Densities (Order Odonata), 1979 - 1980.

Table 7-9. Results of Duncan's Multiple Range Tests for the Main Effects Year and Season, with the Dependent Variable Density for the Order Plecoptera.

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=12003.9

GROUPING	MEAN	N	YEAR
A	32.755208	96	79
A			
A	22.458333	96	80

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=12003.9

GROUPING	MEAN	N	SEASON
A	104.583333	36	FALL
B	10.695000	60	SPRING
B			
B	9.310417	96	SUMMER

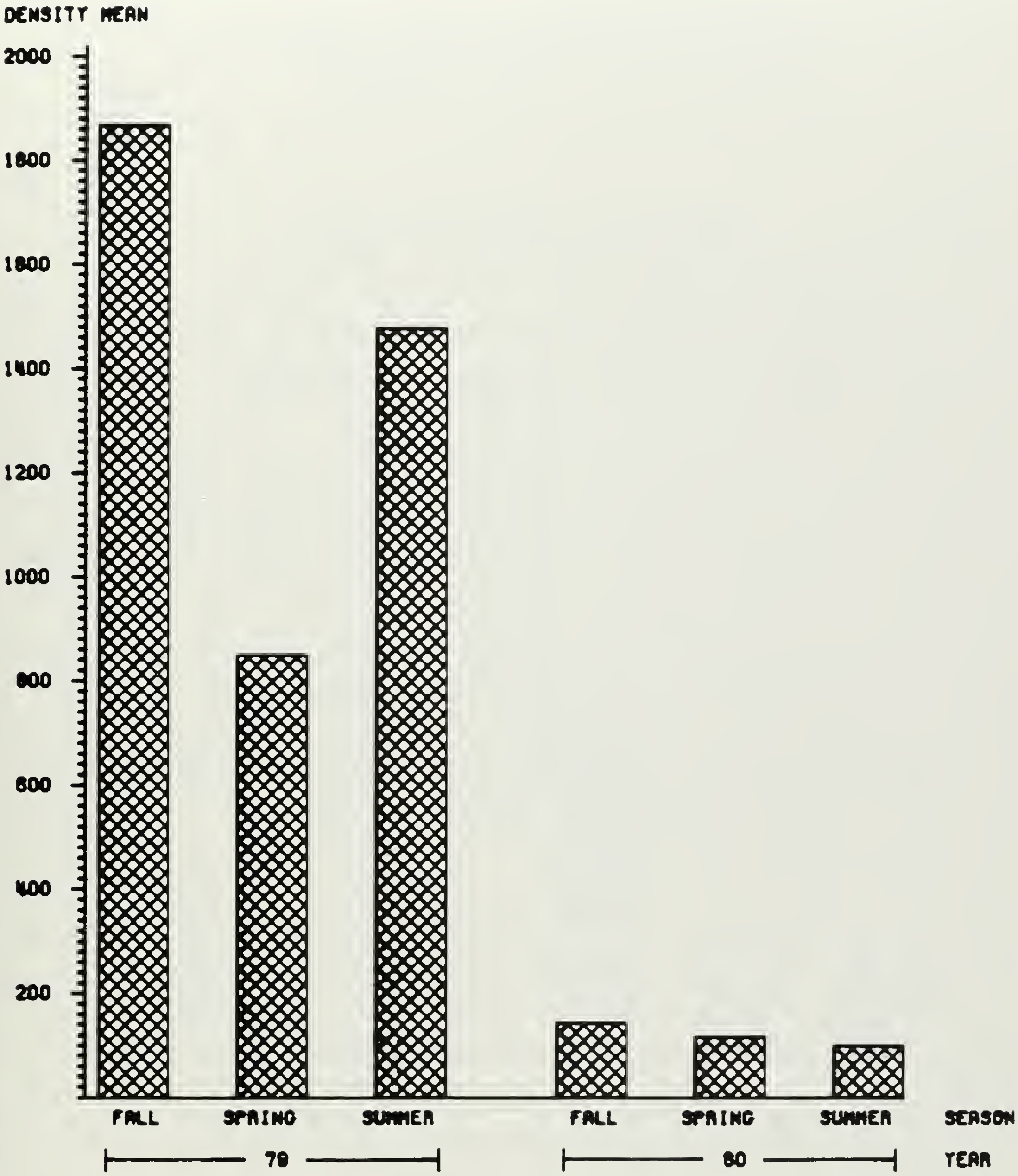

Figure 7-9. Seasonal Changes in Macroinvertebrate Densities (Order Oligochaeta), 1979 - 1980.

Table 7-10. Results of Duncan's Multiple Range Tests for the Main Effects Year and Season, with the Dependent Variable Density for the Order Trichoptera.

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=395283

GROUPING	MEAN	N	YEAR
A	195.181250	96	80
A			
A	78.277083	96	79

GENERAL LINEAR MODELS PROCEDURE

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE DENSITY

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=186 MS=395283

GROUPING	MEAN	N	SEASON
A	430.227778	36	FALL
B	87.503125	96	SUMMER
B			
B	39.391667	60	SPRING

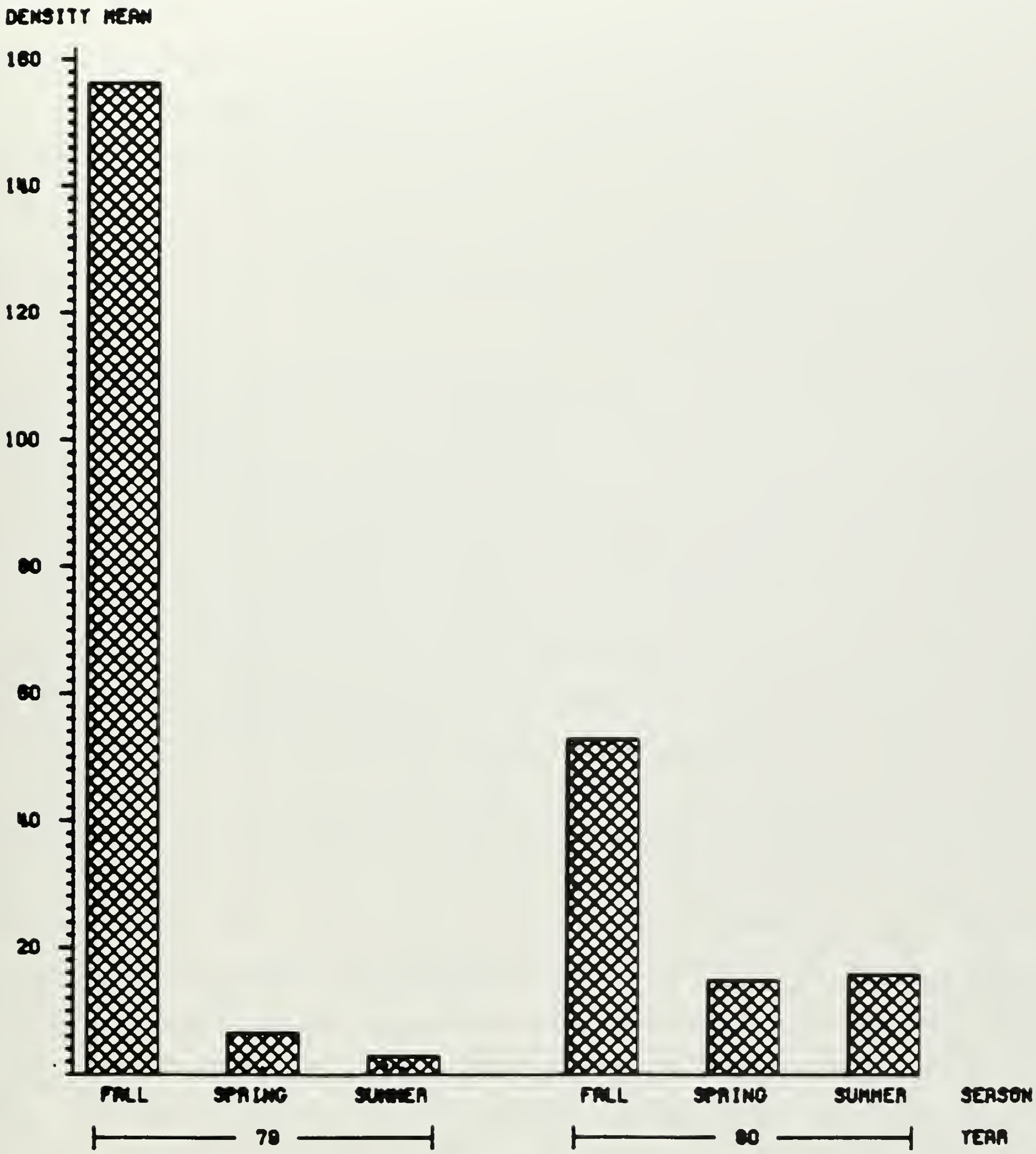

Figure 7-10. Seasonal Changes in Macroinvertebrate Densities (Order Plecoptera), 1979 - 1980.

temperatures. Chironomids have a fairly high tolerance to temperature stress in the environment (Gossner 1971).

The Coleoptera (Aquatic Beetles) have the lowest mean seasonal density and abundance of the major benthic taxa (Figure 7-5). The aquatic beetles sampled near Tract C-a are also holometabolous. Results of the two-way ANOVA (Table 7-4) indicate no significant differences in the seasonal or yearly densities of these insects. All stages of the life cycle remain in the aquatic environment. This may be one explanation why there is no statistically signficant seasonal or yearly differences in the density of aquatic beetles sampled in the Tract C-a ecosystems.

The Ephemeroptera (Mayflies) show a wide variation in mean seasonal densities (Figure 7-6). Results of the two-way ANOVA (Table 7-4) indicate that these insects show no yearly or year by season interaction significance, but do show a fairly high degree of seasonal significance ($\alpha=0.05$). A Duncan's Multiple Range test was used to test the main effects of season and year (Table 7-5). These results indicate that there are no significant differences between the summer and fall and the fall and spring densities, but there is a significant difference between the mean spring and summer Mayfly densities. Mayflies are hemimetabolous species and are subject to seasonal changes in temperature. Data collected thus far seems to indicate that mayfly densities are greatest in the warmer seasons of summer and early fall.

The phylum Nematoda is comprised of the Roundworms. Figure 7-7 indicates a tremendous variability in Nematoda densities at the aquatic sampling stations near Tract C-a. Results of the two-way ANOVA presented in Table 7-4 indicate that no significant seasonal or year by season interaction exists for roundworm densities. There is, however, a significant year term. Results of a Duncan's Multiple Range test (Table 7-6) indicate that mean Nematode densities were quite different between 1979 and 1980. This difference can probably be attributed to increased scouring of the substrate due to larger discharges during 1980.

Dragonflies (Order Odonata) show a wide variation in densities between the fall of 1979 and the fall of 1980 (Figure 7-8). Results of the two-way ANOVA (Table 7-4) indicate that there is a significant year by season interaction term (PR>0.016) and a significant seasonal main effect term (PR>0.0265). Results of a Duncan's Multiple Range test (Table 7-7) indicate that the mean dragonfly densities are higher in the fall of 1980 than in the spring or summer of that year. This difference in seasonal densities should be attributed to natural variability in the ecosystem until more data is examined.

Aquatic worms (Class Oligochaeta) have exhibited the highest densities of the major taxon examined (Figure 7-9). Oligochates also have the widest variation in yearly densities, from less than 200 to over 1800 organisms per square foot for samples collected in 1979 and 1980. Results of the two-way ANOVA (Table 7-4) indicate a high degree of significance for the main effect years, but no seasonal changes in Oligochaeta densities. Results of a Duncan's Multiple Range test (Table 7-8) shows a large difference between the 1979 and 1980 mean Oligochaete densities. These results can probably be attributed to changes in substrate composition at CG-1 that resulted from the scouring effects of discharge activities in 1980. Densities in 1979 were an order of magnitude higher than in 1980 (Figure 7-9).

The Stoneflies are in the Order Plecoptera. Results of the two-way ANOVA (Table 7-4) suggest that a significant seasonal pattern may occur for Plecoptera densities (Table 7-4; Figure 7-10). Examination of Figure 7-10 and results of a Duncan's Multiple Range test (Table 7-8) indicate that fall densities are considerably higher than either spring or summer densities. Stoneflies are hemimetabolous species whose adult stage lives in a terrestrial environment. Stonefly nymphs are found in the aquatic environment. Life history patterns for the Plecoptera indicate that reproduction takes place in the mid to late summer, and that the nymph stage in these species may be protracted over several seasons. This may explain why stonefly nymphs have a higher density in the fall benthic samples.

The Caddisflies (Order Trichoptera) were found to exhibit a significant seasonal main effect (Table 7-4). Results of the Duncan's Multiple Range test (Table 7-10) indicate a seasonal pattern similar to the pattern seen for the Stoneflies; fall densities tend to be higher than the spring or summer densities. This pattern can be explained by examining the general life cycle pattern of caddisflies. Reproduction takes place in the mid to late summer, the offspring are holometabolous, and the larva and pupa are found in the benthic samples collected near Tract C-a.

Seasonal patterns of macroinvertebrate density are an important indicator of the natural variability encountered in the aquatic ecosystems near Tract C-a. As can be seen in Figures 7-4 through 7-10, there is a very wide range in densities over years and seasons. Furthermore, there may be a pattern where by specific taxonomic groups are dominant in specific seasons. As the aquatic program progresses this pattern will be examined to determine if, in fact, specific taxa can be utilized as indicators of change.

7.3 Summary

Seasonal changes in several water quality parameters were examined for the period from 1975 to 1980 at Aquatic Station CG-1. Results of a series of two-way ANOVA's indicated that there is a seasonal pattern for temperature, but not for specific conductance, pH, dissolved oxygen, or alkalinity. The literature cited indicates that temperature changes are a major cause for natural variations in aquatic biota. The other parameters are fairly good indicators of man induced changes in the aquatic biota. Changes in water quality affect the density and composition of the aquatic community; thus, it is important that the natural variabilities in water quality, discussed in Section 7.1, be understood in order to assess man-induced perturbations to the aquatic ecosystems.

Seasonal changes in the densities of the major invertebrate taxa were examined for the period from 1979 to 1980. Results presented for a series of two-way ANOVA's and Duncan's Multiple Range tests indicate a very high degree of natural variability for each taxa. Only one order (Plecoptera) showed a distinct seasonal density pattern. Since these taxa are the consumers in the aquatic ecosystems near Tract C-a, they would serve as good indicators of biotic changes that may be related to man-induced impacts on water quality.

Examination of the changes in the invertebrate community and the effects of changes in the basic water quality on this community are necessary to determine the effects, if any, of Tract C-a development on the aquatic environment. These sections have attempted to account for and explain some of this variability.

Literature Cited

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SECTION 8

SUMMARY

8.0 SUMMARY

Air quality and meteorological data were collected during the six-month reporting period. No unusual events or violations of National Ambient Air Quality Standards occurred. All of the air quality parameters were below the threshold of detection most of the time, with the exception of ozone and particulates. Ozone concentrations ranged from 0.021 to 0.070 ppm at Site 1, and from 0.003 to 0.066 ppm at Site 3. Total suspended particulate concentrations ranged from 4 to 49 $\mu g/m^3$ at the two sites measuring generally background particulate levels (Sites 1 and 2) and from 6 to 57 $\mu g/m^3$ at the site located in Corral Gulch (Site 3), which is often downwind of tract activities. These values are similar to those found in earlier mid-year reports (MDP Monitoring Reports 2 and 4).

No significant changes have been detected in the meteorological data collected during the six-month data period.

A Spring visibility study using both the traditional photometric method and a telephotometer to measure visual range has been initiated but was not completed during this reporting period. The results of the Spring study will be reported in the year-end report, along with the results of the Fall study.

Two noise surveys were taken during the reporting period. During the February survey, sound level averages on the tract ranged from less than 30 to 42 dBA, except when traffic passed the sampling point or near the main construction area (adjacent to headframe). The average sound level in the main construction are averaged 69 dBA. During the May survey, sound level averages ranged from less than 30 to 52 dBA, except for an average of 72 dBA near the main construction area.

The components of the MDP Terrestrial Monitoring Program examined during the reporting period were browse condition and utilization, mule deer density, mule deer road kills, and feral horse abundance.

Browse studies indicate that the weighted average percent utilization ranged from four percent in the sagebrush to eight percent in the pinyon-juniper vegetation type. Utilization in the mixed brush and sagebrush vegetation types decreased relative to 1980 while that for the pinyon-juniper type increased slightly. Range condition ratings based on age class were similar to those evidenced during 1980; however, there is some indication that range condition is improving. Improvements are evident primarily for ratings based on hedging classification, and are probably due to a combination of variations in browse patterns and increased sample size. Because the RBOSC browse studies are designed to census the same individuals on a yearly basis, one would not expect to find large changes in range condition ratings based on age classification.

The average number of mule deer per square mile using the Tract C-a study area during the winter of 1980-81 (24.4), was approximately 65 percent of the number using that area during the 1978-79 winter. This reduction in mule deer density is probably a result of the mild winter which permitted the deer to stay at elevations higher than those of the study area.

The number of mule deer killed by vehicle collisions along Rio Blanco County Road 24 during the reporting period was 7. Eleven deer killed by collisions with vehicles were found there during the same period the previous year. This lower deer kill figure is probably a result of the reduced number of deer which wintered at the lower elevations of County Road 24.

A total of 57 feral horses in 10 bands was counted in the study area during the winter aerial count. The count was down from the 120 horses observed during the 1980 aerial survey.

The data for the physical parameters measured at each aquatic sampling station varied appreciably from year to year. Measurements for April 1981 fell within the range of the previous years, and no large fluctuations were demonstrated by a comparison of the physical and chemical data obtained in April 1980 and April 1981.

The data for the water quality parameters measured in the White River (Stations WR-1 and WR-2) changed very little from baseline conditions. No major differences were found between the water quality data obtained on the White River above and below the confluence with Yellow Creek.

In April 1981 a total of 123 taxa were identified from the periphyton samples. Total mean periphyton densities varied from 16,708 units/mm^2 at Station WR-2 on the White River to 1,598 units/mm^2 at Station CG-1 in Corral Gulch. Total mean periphyton densities in Corral Gulch (Stations CG-1) were higher than the values of April samples in 1978 and 1980 but lower than the values for 1975, 1976 and 1979. Total mean periphyton densities in Yellow Creek (Station YC-3) and the White River (Stations WR-1 and WR-2) during April 1981 were generally higher than in April of previous years.

Taxonomic composition of the major benthic taxa did not change appreciably during April 1981 at stations sampled previously; total densitites were also within the range observed during previous Aprils. A reduction in the number of Chironomids lowered the total density during April 1981 at Station CG-1 as compared to April 1980. Densities at the other three stations sampled previously (YC-3, WR-1 and WR-2) were similar to or greater than April 1980 densities. The dominant taxa over all stations were Chironimidae and Oligochaeta.

The hydrology program provides data necessary to satisfy lease stipulations and conditions of approval from the OSO; assess impacts of dewatering and reinjection (development activities) provide input to engineering design for the mine and water handling system; supply information necessary for environmental disciplines to evaluate impacts and mitigation; and collect data for compliance with permit stipulations. Stream gaging and erosion stations, springs and seeps, alluvial and deep aquifer holes, surface water impoundment, discharges, and reinjection and dewatering wells were monitored.

The results of the hydrology program are summarized below:

- Surface Water - Of the six gaging stations monitored, Dry Fork failed to show any flow during the reporting period. During most of the reporting period, there were no surface discharges.

- Springs and Seeps - Physical data for all springs and seeps fell within baseline ranges with the exception of Station No. 14 on Corral Gulch.

- Alluvial Groundwater - Many of the alluvial wells remained dry throughout the reporting period, a condition similar to that experienced during baseline monitoring. Physical data for the alluvial wells generally fluctuated within baseline ranges.

- Upper and Lower Aquifer Water - Natural recharge to the upper aquifer occurred in the west, northwest and southern portions of the tract.

- Development Activities - A booster pump was installed in Box Elder Gulch to increase the reinjection rate to the south.

The data for the physical parameters measured at each aquatic sampling station varied appreciably from year to year. Measurements for April 1981 fell within the range of the previous years, and no large fluctuations were demonstrated by a comparison of the physical and chemical data obtained in April 1980 and April 1981.

The data for the water quality parameters measured in the White River (Stations WR-1 and WR-2) changed very little from baseline conditions. No major differences were found between the water quality data obtained on the White River above and below the confluence with Yellow Creek.

In April 1981 a total of 123 taxa were identified from the periphyton samples. Total mean periphyton densitites varied from 16,708 units/mm^2 at station WR-2 on the White River to 1598 units/mm^2 at Station CG-1 in Corral Gulch. Total mean periphyton densitites in Corral Gulch (Station CG-1) were higher than the values of April samples in 1978 and 1980 but lower than the values for 1975, 1976 and 1979. Total mean periphyton densities in Yellow Creek (Station YC-3) and the White River (Stations WR-1 and WR-2) during April 1981 were generally higher than in April of previous years.

Taxonomic composition of the major benthic taxa did not change appreciably during April 1981 at stations sampled previously; total densities were also within the range observed during previous Aprils. A reduction in the number of Chironomids lowered the total density during April 1981 at Station CG-1 as compared to April 1980. Densities at the other three stations sampled previously (YC-3, WR- 1 and WR-2) were similar to or greater than April 1980 densitites. The dominant taxa over all stations were Chironimadae and Oligochaeta.